PRODUCT ENGINEERING

FEBRUARY, 1950

STANDARDIZED COMPONENTS SPEED SERVOMECHANISM DEVELOPMENT

IN THIS ISSUE—Experimental Fixtures + Retaining Rings + Weldability of Metals by Resistance Welding + Taper Gear Design + Electrical Control by Amplistats

A McGRAW-HILL PUBLICATION

NI-RESIST...
AN ECONOMICAL METAL

for resisting Corrosion, Erosion and Metal-to-Metal Wear

NI-RESIST® is the trade name of a high nickel cast iron – one of the most economical corrosion-resistant engineering materials ever developed.

NI-RESIST, mechanically similar to gray iron, and resembling austenitic stainless steel in many characteristics, provides a unique combination of properties at moderate cost . . .

RESISTS CORROSION

NI-RESIST resists corrosive attacks of *acids*, *alkalies* and *salts* to a degree unmatched by any other product of the cast iron industry. In strong corrosives it has 20 to 200 times the resistance of plain iron, and 5 to 50 times the resistance in mild environments.

CURBS WEAR

NI-RESIST reduces wear and galling, because graphite particles are distributed throughout its structure, as in gray iron. From this, and its work-hardening characteristics, come the superiority of NI-RESIST castings for components in metal-to-metal wear service.

CHECKS EROSION

This superior wear-resistance . . . together with inherent resistance to corrosion . . . makes NI-RESIST an outstanding material for curbing erosion by liquids and slurries. By long, trouble-free control of erosion, NI-RESIST castings reduce maintenance costs, production tie-ups and the expense of replacements.

WITHSTANDS HEAT

Although primarily used to resist corrosion, erosion and metal-to-metal wear . . . NI-RESIST is also specified for resistance to elevated temperature effects. Castings of NI-RESIST show up to 10 times better scaling resistance, and up to 12 times better growth resistance than those of plain iron at 1300 to 1500° F.

MACHINABILITY and OTHER PROPERTIES

NI-RESIST of normal hardness machines like 200 BHN gray iron and is readily weldable.

NI-RESIST has high specific electrical resistance. Thermal expansion can be controlled, from 60 per cent higher than that of plain iron to a low approximating that of Invar.

NI-RESIST is usually lower in cost than most other corrosion-resistant alloys. It is produced by authorized foundries only, in all industrial centers of the country. NI-RESIST castings have no more limitations in size and complexity than those of any gray iron.

APPLICATIONS

Several types of NI-RESIST *are available. All provide the fundamental properties described above, and differ only in certain special characteristics to meet a variety of industrial demands.*

Applications include: Salt filter drums, oil refinery tube supports and headers, turbine nozzle rings, cylinder liners, valves and fittings, furnace rollers, textile rolls, comminuter parts, blow pit pipes, precision machine tool spindle heads, bridge, and work supports, magnet housings, sugar retorts, etc.

FULL INFORMATION

May we send you two booklets? One, entitled, "Engineering Properties and Applications of NI-RESIST," includes corrosion data on NI-RESIST and cast iron under 400 different corrosive conditions. The other, entitled, "Buyers' Guide for NI-RESIST Castings," lists producers of NI-RESIST castings. Both are yours for the asking. Write for them today.

®Reg. U. S. Pat. Off.

EMBLEM OF INCO SERVICE TRADE MARK

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

VOLUME 21 — PRODUCT ENGINEERING — NUMBER 2

G. F. NORDENHOLT, *Editor*

Assistant to the Editor, Joseph Kerr • *Managing Editor*, James R. Bright • *Associate Editors*, Harold Schor V. H. Laughner, F. H. Fowler, Jr. • *Assistant Editors*, E. S. Cobb, J. D. Cooney, W. B. Eidson, N. J. Van Ness *Consulting Editor*, Robert E. Bruckner • *Washington*, George B. Bryant, Jr. *Publisher*, Albert Hauptli • *Assistant Publisher*, W. E. Kennedy

Foreign News Bureau: London • Paris • Berlin • Moscow • Tokyo • Bombay • Melbourne • Rio de Janiero • Buenos Aires

FEBRUARY 1950

D-c Power Control With Amplistats by W. L. O. Graves and H. M. Ogle. 81
Circuits and operating characteristics of a new type of static d-c power control device.

Hot Forming of 75S-T Aluminum by A. L. Schoellerman 85
Evaluation of two resistance heating methods for hot forming high strength sheet.

Weldability of Metals by Resistance Welding Techniques by W. A. Stanley 88
What results to expect when specifying resistance welding for parts formed of various metals.

Product Designs 92
Compound airplane engine; Tractor attachment; Electronic flow meter; Spun air vent.

Mechanical and Electrical Analogues for Vibration Problems by Walter W. Soroka. . . . 104
Analogue models for measuring frequencies of coupled vibrations in machines on resilient mounts.

Silicone Surface Coatings by M. A. Glaser 109
Specifications, physical and chemical properties of these new heat resistant finishes.

Stainless Steel Rivets by Roy A. Miller. 112
Design recommendations for stainless steel rivets used to join aluminum or alloy steel sheet.

Casting Design as Influenced by Foundry Practice by Oliver Smalley. 117
Ten rules which the designer should apply to facilitate production.

Standardized Parts Speed Servomechanism Development by J. G. Cunningham. 122
The use of prefabricated breadboard systems in the design of mechanical assemblies.

Selection and Use of Retaining Rings by Henrich Heinmann. 124
Of the many stamped retaining rings, which are the common types and when should each be used.

Effect of Axis Angle on Tapered Gear Design by George Sanborn and Ben Bloomfield . . . 129
Establishing design limitations on tapered gears with intersecting and non-intersecting axis.

Fundamentals of Storage Batteries. 133
Operating characteristics and other factors that must be considered when applying storage batteries.

Operating Principles of Temperature Measuring Devices. 138
Various types of instruments and special methods for temperature measurement.

Simplified Design Procedure for Helical Wire Springs by August J. Kwosek. 140
Data for a simplified solution of helical compression and extension spring design problems.

Deflections of Rubber Compression Sandwiches 153
Charts and diagrams for calculating deflection from the load, the shape and the dimensions.

Extent of Flange Stress Concentration Region 157
Where to locate stress raisers to reduce their detrimental effects.

FRONT COVER—A designer studies the system response of a servomechanism built of standardized fixtures. With these "prefabricated" breadboard models, effects of modification can be explored with minimum delay in constructing the model. Kodachrome courtesy of Reeves Instrument Company.

DEPARTMENTS

Highlights 3
Editorial 79
Engineering Abstracts . . . 144
New Components, Parts, and Materials. 158
Technical News 147
Our Readers Say. 186
Meetings 202
New Books 204

Publication Office: 99-129 North Broadway, Albany 1, N. Y. Return postage guaranteed. **Published monthly** by McGraw-Hill Publishing Company, Inc., James H. McGraw (1860-1948), Founder; James H. McGraw, Jr., President; Curtis W. McGraw, Vice-President and Treasurer; Eugene Duffield, Senior Vice-President. Publications Division: Nelson Bond, Vice-President and Director of Advertising; Joseph A. Gerardi, Secretary; J. E. Blackburn, Jr., Vice-President and Director of Circulation. **Correspondence About Subscriptions** should be addressed to Director of Circulation, Product Engineering, 330 W. 42nd St., New York 18. Allow at least 10 days for change of address. Indicate position and company connection on all subscription orders.

Subscription Rates: Single copies 75c. United States and possessions, $6 for one year, $9 for two years, $12 for three years; Canada, $7 for one year, $11 for two years, $14 for three years; Latin American countries, $10 for one year, $16 for two years, $20 for three years; all other countries, $15 for one year, $25 for two years, $30 for three years.

Editorial and Executive Offices: 330 W. 42nd St., New York 18. Cable address: "McGraw-Hill," N. Y.

Branch Offices: ATLANTA, R. H. Maultsby, 1311 Rhodes-Haverty Bldg.; BOSTON, M. A. Williamson, Jr., 1427 Statler Bldg.; CHICAGO, Anson E. Meanor, 520 N. Michigan Ave.; CINCINNATI, R. H. Anderson, 1110 Delta Ave.; CLEVELAND, A. F. Tischer and R. H. Anderson, 1510 Hanna Bldg.; DALLAS, J. H. Allen, First National Bank Bldg.; DETROIT, G. F. Weatherby, 2360 Penobscot Bldg.; LOS ANGELES, C. W. Dyainger, 621 S. Bone St.; NEW YORK, J. A. McGrave, Hugh Britton, 330 W. 42nd St.; PHILADELPHIA, David G. Jones, Architects Bldg.; PITTSBURGH, A. F. Tischer, 706-9 Oliver Bldg.; SAN FRANCISCO, J. W. Otterson, 68 Post St.; WASHINGTON, National Press Bldg.; LONDON, Aldwych House, Aldwych, W. C. 2, England.

Entered as second-class matter Aug. 21, 1936, at Post Office, Albany, N. Y., under act of Mar. 3, 1879. Printed in U. S. A. Member of A.B.P., A.B.C. Copyright 1950 by McGraw-Hill Publishing Co., Inc. All rights reserved.

Critical Requirements of Television Prove

Remarkable Performance of Mallory FP Capacitors!

There can be no more convincing proof of superiority than the performance records hung up by Mallory FP Capacitors in the demanding field of television service.

In one case, an outstanding television manufacturer kept detailed records of field failures of component parts over a six month period . . . found only six Mallory failures, with nearly 400,000 FP Capacitors in service!

That's service beyond expectations!

That's why so many leading manufacturers insist on Mallory Capacitors that have set the pace in the industry for years. That's why you should specify Mallory, at no premium in price, for any application that demands continuous, trouble-free performance.

MALLORY FP CAPACITORS

Mallory FP Capacitors are designed to operate continuously at 85° C—and are famous for their long *shelf life*. Write for your copy of the Mallory FP Capacitor data folder.

FP is the type designation of the Mallory-developed electrolytic capacitor having the characteristic design pictured and famous throughout the industry for dependable performance.

P. R. MALLORY & CO. Inc.

MALLORY

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

SERVING INDUSTRY WITH

Capacitors	Contacts
Controls	Resistors
Rectifiers	Vibrators
Special Switches	Power Supplies

Resistance Welding Materials

Highlights

In this summary of technical developments, space restrictions do not allow giving complete details. Further information relating to any item can be obtained by writing to the Editor of Product Engineering.

Metallic Materials

COPPER IN PASTE FORM can be the source of appreciable time savings in the assembly of parts for furnace brazing. Special applicator guns extrude rounds or ribbons of the paste in either of two forms – a petroleum base type that flows into a joint when heated or a constant-viscosity type that "stays put". Finely divided iron powder mixed with the paste produces a cement that's useful in cases where loose fits for expansion purposes are required, when cracks and loose joints must be filled or special fillets are needed.

NODULAR GRAPHITE Meehanite metal is now available on a commercial scale. The switch-over to production of this increasingly-popular form of ductile alloy has been a relatively simple one, because the high-strength properties of Meehanite castings have always been dependent on precise heat treatment.

ZIRCONIUM-BORON COMPOUND may be the answer to jet and rocket engine high-temperature materials problem. Now under test by the Navy, alloy is reported to withstand 3,000-F heat while subjected to stresses of 50,000 to 75,000 pounds per square inch.

CHROME-NICKEL STEEL of the austenitic stainless class work-hardens more slowly than the 18-8 type and therefore will be good news for fabricators of fasteners that require extreme cold-heading and upsetting. Percent composition is 0.08 C, 16.0 Cr and 18.0 Ni; tensile strength is 75,000 psi; and percent elongation in 2 in. is 55. Comes as forging billets, hot-rolled bars and forgings, cold-drawn and ground bars.

ENTHUSIASM FOR TITANIUM as the cure-all for metals application problems may be tempered by the results of recent Wright Field creep investigations. Both annealed and cold-rolled samples exhibited failures at stresses below the yield point when tested at room temperatures.

Nonmetallic Materials

MULTIPLE-COLORED PRODUCTS usually require separate, time-consuming sprays and/or bakes for each color area. Not so with a new coating that comes in all standard colors, either glossy or full flat. One area is coated and dried for 5 min; different colors are then applied to other areas at 5-min intervals. A single bake then seals all finishes on metal, wood, plastic or glass materials.

SHOE SHINE ARTISTS will shudder the day they learn that leather can be combined with rubber to produce a highly durable material. When soaked over night in a rubber solution and then vulcanized, low-grade leather absorbs only half as much water as untreated hides and is twice as resistant to abrasion.

ALKYD PUTTY has many advantages when used in electrical components such as capacitors, condensers, resistors, tube bases, wire connectors, time switches and motor starters. Compound requires 500 to 1,000 psi mold pressure at 250 to 300 F, cures rapidly – in 5 to 10 sec for a part 1/8 in. thick; in 30 to 90 sec for a 1/2 in. piece.

PLASTIC FILM applied like tape and then heat treated cures to form electrical insulation having a dielectric strength of about 1,750 v per mil. Fully-cured cherry-red layer protects coil windings from moisture, oil,

Continued on Page 5

Example { 5½ hp at 870 rpm; 60 to 1; Class 1 service

Here's what Cone-Drive double-enveloping gears save you in speed reducers*

To handle this load would call for one of these

For the same load carrying capacity:

8" Fan Cooled Non-Cone-Drive costs . . $95 less

7" Heavy-Duty CONE-DRIVE costs . . $113 less

6" Fan Cooled CONE-DRIVE costs . . $257 less

*—Based on approximate resale prices, Jan. 1st, 1950

. . . and similar savings on gear sets

Cone-Drive Gears and Reducers handle more load—cost less, due to Cone Drive's double-enveloping gearing.

In Cone-Drive you can also get the triple benefits of

Standard gears
Standard housings
Standard fan-cooled attachments

CONE-DRIVE GEARS

DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS

Division, Michigan Tool Company

7171 E. McNichols Road • Detroit 12, Michigan

solvents and chemicals; withstands temperatures in excess of the values associated with rubber and vinyl insulation.

CLOGGING of oil-burner filters will be a nuisance of the past, at least for those using Shell's 1950-grade heating oil. A "secret" ingredient reportedly counteracts coagulation of microscopic substances present in many standard heating fuels.

Testing

A PROJECTILE'S SPEED is relatively simple to measure, but recording its rate of spin during flight is a good trick. Here's one way: Insert a shielded, magnetized, steel slug in the missile at right angles to its axis. Mount a rectangular, wire-wound coil parallel to the line of flight and feed the amplified output signal of the coil into an oscillograph. The resulting curve trace can then be photographed for subsequent analysis.

MAGNIFYING MICROMETER measures thickness of plating, paint and enamel applied to a magnetic base such as nickel on steel. As the barrel thimble is turned, a spring pulls on a permanent magnet until it "lets go" suddenly. The height to which an indicator pin extends above the barrel is calibrated in terms of a coating's thickness.

ABSOLUTE VALUES for the hardness of materials are claimed for a new scale worked out by a Russian. An equation involving the cube root of the Vickers penetrator micro-hardness boils down to a nearly linear relationship of values for the whole gamut of materials from talc to diamonds.

SLICING METAL into transparent shavings 0.000002 in. thick is possible with a microtome that cuts by means of air waves. Stock is held in an adjustable chuck that positions it close to, but not touching, the blade. As the blade rotates at 65,000 rpm, shock waves generated at the tip shave sections from the material in thicknesses determined by the spacing between blade and stock.

ELECTRONIC SOUND PROBE is a real detective for tracking down noises in machinery. While tuning out "foreign" sounds, device spots the offending member and amplifies the noise, even the tick of a fine watch, as the operator listens through a pair of earphones.

Components

DOUBLE-ACTING air cylinder has a false piston or stop that varies the displacement. One end of the piston is a hollow, internally threaded connecting screw, locked with a star wheel, that allows air to pass through one cylinder head; other head has conventional side porting.

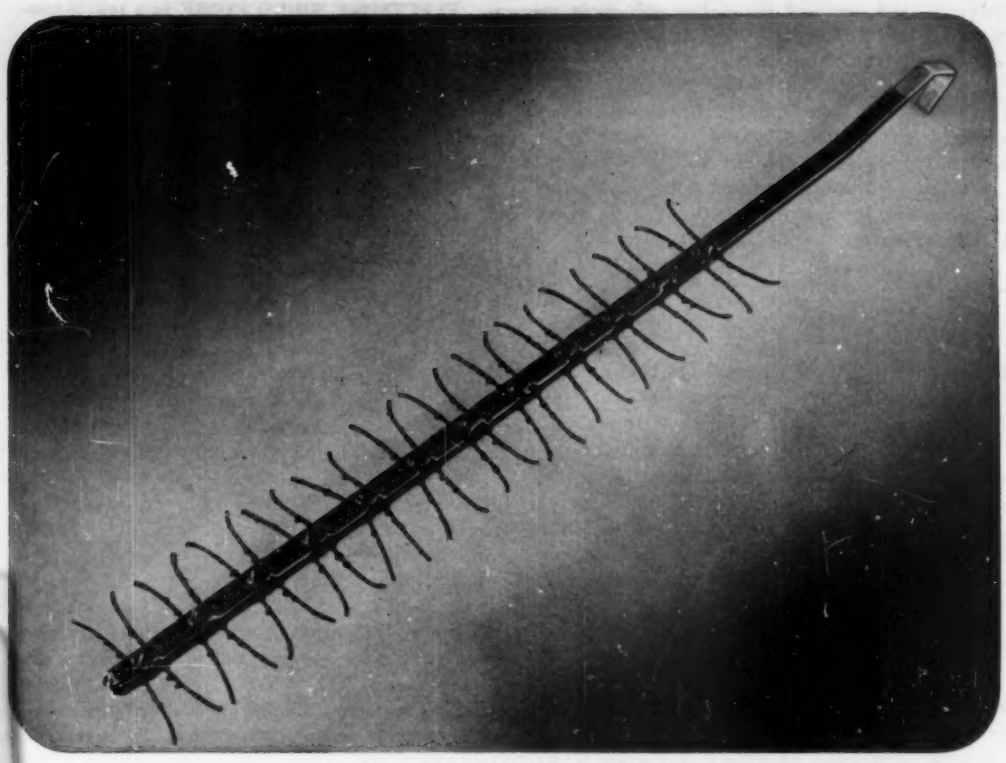
A SINGLE-PIN CONNECTOR combines the low-cost and long-life features of riveted chains with the ease-of-assembly characteristic of roller chains. Inserted at the 2-ft mark and end of a 5-ft length of chain, connector is a rivet and a detachable pin that has a spun-over washer at one end and a milled flat with cotter pin at the other. Special link has a distinct tear-drop shape that makes identification a simple matter.

STARTING SWITCH for manual control of electric motors from 1/12 to 1/2 hp also protects unit from overheating when motor stalls or load is excessive. Thermal disk prevents restarting until overload is cleared and motor has cooled. No built-in centrifugal, "on-off" or separate reset switch is necessary.

WEDGING of the brushes in series-wound fractional-hp motors is prevented by a stabilizing mechanism that is interchangeable with NEMA assemblies. By using an angular-topped brush and a special mating bracket, brush-spring pressure is partially resolved into a horizontal component that damps vibrations and counteracts wedging against commutator and brush holder.

TINNED-COPPER WIRE has only a 1/32 in. vinyl plastic wall of insulation, yet the Underwriters' Laboratories have given their approval for continuous use at temperatures up to 105 C.

Continued on Page 7



Geon plastisol coating by the Chemical Division, Michigan Chrome and Chemical Company, Detroit, Michigan.

Less of it lasts longer ...that's a GEON coating!

THE picture above shows a plating rack coated with a plastisol made from Geon paste resin. The rack was used for *six months* in a copper-nickel-chrome plating cycle. The protective Geon coating *still* adheres tightly and shows little effect from the corrosive baths or electrical current.

With plastisols made from Geon paste resin, seldom more than two coatings are required for racks—in many cases only one. Formerly, from seven to ten solution coatings were needed. These often failed after two or three weeks' service. What a difference Geon makes!

Think of these extra advantages. Plastisols made from Geon paste resin make it possible, for the first time, to single dip and obtain pickup weights that cover most field requirements. Coatings can be applied with thicknesses ranging from a few mils to ¼" or more per dip.

They're highly resistant to chemicals and abrasion. They can be compounded in a wide color range. They're easy to process—safely and at low cost.

There are many uses for Geon paste resin—coating textiles, paper and fiberglass . . . dip-coating plating racks, gloves, dish racks, etc. . . . molding toys and dolls, prosthetic devices, artificial fish lures, mechanical parts. Geon may be just what you're looking for to improve or develop more saleable products, cut costs, help you increase your sales. For further information, please write Dept. GO-1, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio.

B. F. Goodrich Chemical Company A DIVISION OF THE B. F. GOODRICH COMPANY

GEON polyvinyl materials • HYCAR American rubber • GOOD-RITE chemicals and plasticizers

Absence of overbraids and jackets means less weight and bulk, as well as greatly reduced inventories through standardization on fewer types of wire.

MINIATURE storage batteries half the size of and one-fifth the weight of standard alkaline units have silver and zinc active materials. Available in five 1.5-v sizes ranging from 0.8 to 40 amp-hr. Latter weighs only 23 oz, measures 4 in. high, 4.3 in. long.

Processes

LOW-COST WELDING of copper to itself or steel by the Cadwell process, a variation of the Thermit technique. Copper oxide replaces the iron oxide and is reduced by aluminum oxide in a graphite crucible-mold at 4,000 F. Molten copper melts a steel disk placed over the mold hole and runs into mold containing parts that are to be welded.

REFRACTORY COATINGS vapor-deposited on molybdenum are proving successful for high-temperature use. Samples have survived 5,000 hr at 1,800 F and even 3,100 F for 200 hours.

WARTIME TECHNIQUES used for aircraft engine sleeve bearings are being applied to diesels. Steel backing-shells are machined to close tolerances and heated in a flask, prior to pouring of high-grade molten bronze. Flask is then rotated during final quench.

IMMERSION PLATING of aluminum with sulphate-solutions of zinc, cadmium or tin, followed by electroplated coatings of nickel and chromium is equally as speedy a process as the alkaline zincate dip method.

PRE-SPUN SHAPES instead of flat metal blanks cut the cost of drop-hammer forming operations – fewer staging dies are needed, better control of metal thinning is achieved and rejections are greatly reduced. When dealing with aluminum parts, 3S is used for unstressed members, 61S for stressed units. Brass, terne plate, stainless and body steel also can be used.

VACUUM METALLIZING on a continuous instead of a batch basis is gaining favor. Any material that remains a solid and has a vapor pressure low enough to permit a 0.1-micron vacuum can be deposited. Aluminum, copper, gold, magnesium fluoride, nickel, silver and zinc can be coated on each other or on glass, plastics, paper or cloth.

Products

CONVERTIBLE AIRPLANES are not just Buck Rogers dreams. According to calculations made by NACA engineers, a propeller-like rotor with high disk loading will fill the bill for a plane that can take off and land like a helicopter and cruise like a monoplane.

SYNCHRONOUS CAMERA weighing only 4 lb has shutter speeds of 1/25 to 1/200 sec for exposures of 4, 8, 16 and 32 frames per sec. Timing and coding lights mark 50-ft film for location of any given frame or sequence of exposures. A built-in clutch prevents the gain or loss of a frame over full length of film.

JET-PROPELLED transports may not be too far off – maybe a year or two – now that GE's J-47 powerplant has been given CAA approval for commercial use. The 5,000-hp unit has several thousand hours of ground and flight testing to its credit.

NASH is soliciting the motoring public's reaction to a small car that could, if produced, be sold for $1,000 or less. Sketch shows sunken hood and continuous fender line from front to rear. The four-cylinder foreign-built motor can be either 18 or 36 hp with a gas-mileage of 35 to 50 mpg. The front end – hood, fenders, headlights and all can be lifted as a unit. Bumper and grille are one piece as on the Buick Special introduced last summer.

A 200-TON STEEL BLOCK, the size of a railroad box-car, isn't too much for a combination planer-milling machine just completed. The 40-ft table moves under a 27-ft arch at 3 to 45 in. per min when milling or at 10 to 150 ft per min when planing.

● Now Revere can supply your needs for *aluminum alloys* in the form of extruded shapes, coiled sheets, tube, forgings.

As a supplier of copper alloy products, Revere earned its position of leadership through uniformity of quality and a really helpful Technical Advisory Service. You can be sure of equally good products and equally helpful service when you use Revere Aluminum.

The Technical Advisory Service can help you most when your products are still in the design stage. So, whether you're thinking of aluminum or copper, or both, may we work with you *now* on the products you are developing for tomorrow?

SEND FOR THIS BOOKLET!

"Revere Alluminum Alloys" describes the aluminum alloys furnished by Revere, gives you the properties of each, and shows many of the products being made from them. Write for your copy today!

REVERE

COPPER AND BRASS INCORPORATED

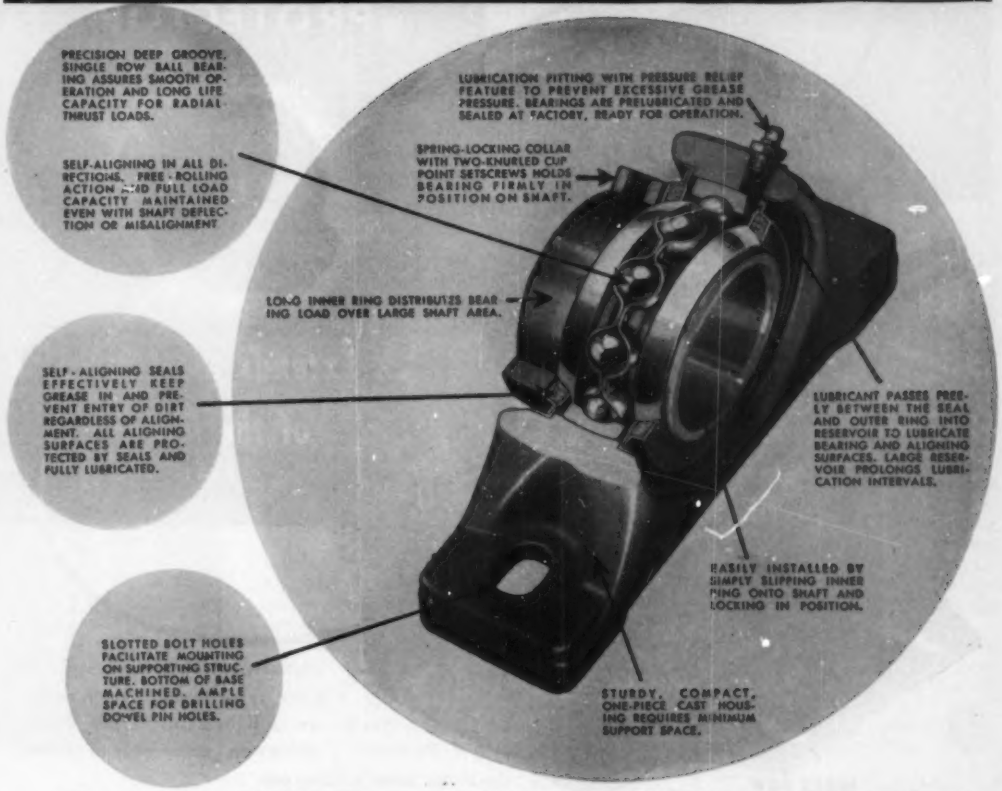
Founded by Paul Revere in 1801

230 Park Avenue, New York 17, New York

• • •

Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Rome, N. Y. Sales Offices in Principal Cities.

PLUS VALUES in Series 200 LINK-BELT *Ball Bearing* BLOCKS


PRECISION DEEP GROOVE, SINGLE ROW BALL BEARING ASSURES SMOOTH OPERATION AND LONG LIFE. CAPACITY FOR RADIAL THRUST LOADS.
SELF-ALIGNING IN ALL DIRECTIONS. FREE-ROLLING ACTION AND FULL LOAD CAPACITY MAINTAINED EVEN WITH SHAFT DEFLECTION OR MISALIGNMENT
SELF-ALIGNING SEALS EFFECTIVELY KEEP GREASE IN AND PREVENT ENTRY OF DIRT REGARDLESS OF ALIGNMENT. ALL ALIGNING SURFACES ARE PROTECTED BY SEALS AND FULLY LUBRICATED.
SLOTTED BOLT HOLES FACILITATE MOUNTING ON SUPPORTING STRUCTURE. BOTTOM OF BASE MACHINED. AMPLE SPACE FOR DRILLING DOWEL PIN HOLES.
LUBRICATION FITTING WITH PRESSURE RELIEF FEATURE TO PREVENT EXCESSIVE GREASE PRESSURE. BEARINGS ARE PRELUBRICATED AND SEALED AT FACTORY, READY FOR OPERATION.
SPRING-LOCKING COLLAR WITH TWO-KNURLED CUP POINT SETSCREWS HOLDS BEARING FIRMLY IN POSITION ON SHAFT.
LONG INNER RING DISTRIBUTES BEARING LOAD OVER LARGE SHAFT AREA.
LUBRICANT PASSES FREELY BETWEEN THE SEAL AND OUTER RING INTO RESERVOIR TO LUBRICATE BEARING AND ALIGNING SURFACES. LARGE RESERVOIR PROLONGS LUBRICATION INTERVALS.
EASILY INSTALLED BY SIMPLY SLIPPING INNER RING ONTO SHAFT AND LOCKING IN POSITION.
STURDY, COMPACT, ONE-PIECE CAST HOUSING REQUIRES MINIMUM SUPPORT SPACE.

Send for Catalog No. 2550

Highlighted above are several of the PLUS VALUES built into Series 200 Link-Belt Ball Bearing Pillow Blocks. No wonder bearing users are specifying LINK-BELT more and more . . . for dependability, for free-rolling action, for economy. Link-Belt Company — serving industry since 1875 — offers a COMPLETE LINE of mounted and unmounted Ball and Roller Bearings for every type of industrial application.

VARIETY OF MOUNTINGS for WIDE RANGE OF APPLICATIONS

LINK-BELT COMPANY

Indianapolis 6, Chicago 9, Philadelphia 40, Atlanta, Dallas 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8.
Offices, Factory Branch Stores and Distributors in Principal Cities. 11,701

THIS KLIXON PROTECTOR

Extends the Life Line of the Motor

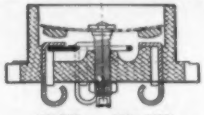
Illustrated above is cross section of a motor . . . and when you look inside, you'll see a Klixon Automatic Motor Protector . . . always on guard, ready to prevent the motor from burning out.

Built-in as an inherent part by the motor manufacturer, the Klixon Protector *protects* the motor by cutting "off" the power should the motor become dangerously overheated. When it cools to safety, the protector snaps the power "on" again automatically.

Regardless of the motors or motor-driven products you manufacture, it will be to your advantage to use and specify motors with built-in Klixon Protectors. They are available in automatic reset and manual reset types in a wide range of ratings.

Remember, too, Klixon Protectors in transformers, solenoids, variable voltage transformers and other electrical equipment keep them from burning out.

HERE'S HOW KLIXON PROTECTION WORKS



CLICK! . . . IT'S OFF!

Should a motor become overheated and dangerously hot, the Klixon Protector snaps the power "off" preventing the motor from burning out.

CLICK! . . . IT'S ON!

When the motor cools to safety, the Klixon Protector snaps the power "on" automatically, or by pushing the red button when the manual reset type is used.

KLIXON

SPENCER THERMOSTAT
Division of Metals & Controls Corporation
902 FOREST ST., ATTLEBORO, MASS.

Cork makes rubber gaskets stay put on oily flanges

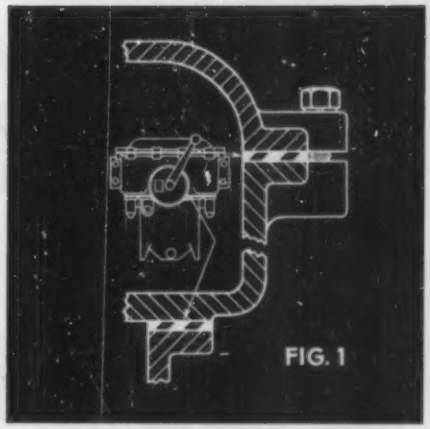


FIG. 1

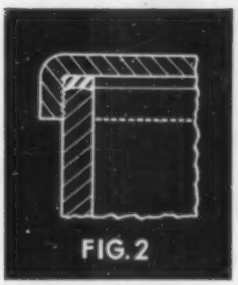


FIG. 2

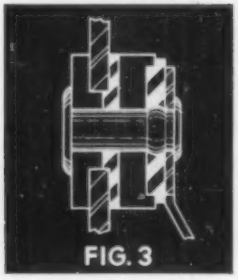


FIG. 3

Straight rubber gaskets tend to slip out of place on oily flanges. They flow laterally in any unconfined direction—even on dry flanges—because straight rubber is non-compressible.

When the restraining friction of flange surfaces is reduced by an oily film, the gasket often extrudes from between the flanges. Thus, greases, cutting oils, etc., deposited on flanges during fabrication may upset load calculation based on dry rubber between clean flanges. This in turn can cause a faulty or ineffective seal.

This problem is overcome by adding truly compressible cork particles to the rubber, as in Armstrong's Cork-and-Rubber. The cellular nature of cork permits cork-and-rubber to compress on itself, actually decreasing in volume. Thus side-flow can be controlled within desired limits or completely eliminated.

Furthermore, cork retains much of its naturally high friction, even when coated with an oily film. This unique property acts to further impede movement.

On the oil-filled circuit breaker (figure 1), for example, sealing oily flanges with straight rubber caused trouble during assembly and field maintenance. By switching to the right cork-and-rubber composition, excessive side-flow was eliminated and the gasket stayed in place.

Cutting oil lubricated the rubber gasket on the tank flange in figure 2. When the screw-on cover was tightened, the gasket tended to squeeze out of place. Cork-and-rubber, on the other hand, seals tightly because it does not slip off the flange.

Seepage of insulating oil was a frequent complaint when straight rubber was used to seal the riveted condenser terminal assembly in figure 3. Now cork-and-rubber provides an effective seal that lasts for the life of the condenser.

For further information on the effect of flange condition on sealing, refer to page 21 of Armstrong's Gasket and Sealing Materials offered below or call your nearest Armstrong representative for specific suggestions.

Send for this Gasket Handbook

You'll find useful application and specification data in the revised 24-page booklet, "Armstrong's Gasket and Sealing Materials." It contains up-to-date information on straight synthetic rubber, cork-and-synthetic-rubber, and cork composition gasket and sealing materials.

This booklet includes ten technical discussions of the factors influencing modern gasket and joint design. It also suggests methods of putting Armstrong's stock materials to specialized uses in such fields as radio, electrical, automotive, petroleum, and transportation industries.

For your free copy, fill in coupon at right and mail today.

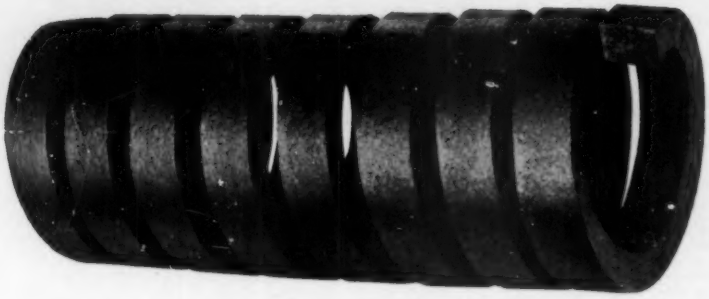
ARMSTRONG CORK CO.
Gaskets and Packings Dept.
7102 Arch Street, Lancaster, Pa.

Please send me at once a free copy of the new 24-page booklet, "Armstrong's Gasket and Sealing Materials."

NAME.....
COMPANY.....
ADDRESS.....
CITY.....STATE.....

ARMSTRONG'S
GASKETS • PACKINGS • SEALS

SPECIFY
versi-pak®
A NEW AND HIGHLY VERSATILE PLASTIC PACKING



versi-pak is the result of more than two years of testing and development. This new plastic packing can be used in an exceptionally large number of applications. It is now being used successfully in reciprocating and centrifugal equipment and in hydraulic systems. Recommended for temperatures up to 350°F., pressures up to 600 p.s.i., against air, water, low-pressure steam, and a long list of chemicals. Available also in non-graphited form (R/M No. 1846) for use in food-handling equipment. For further information and your free copy of the new bulletin on **versi-pak** send the coupon below to the Packing Division, Manheim, Pa.

RAYBESTOS-MANHATTAN, INC.
PACKING DIVISION, MANHEIM, PA.

FACTORIES: Bridgeport, Conn.; Manheim, Pa.
No. Charleston, S.C.; Passaic, N.J.

Raybestos-Manhattan, Inc.
Packing Division, Manheim, Pa.

Gentlemen: ☐ Please send me a free copy of the **versi-pak** bulletin.

Name_____

Position_____

Company_____

Address_____

City_____ Zone____ State_____

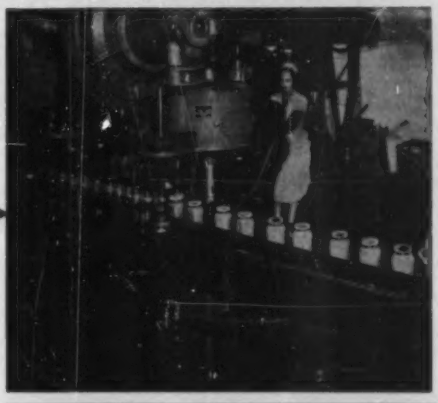
RM

RAYBESTOS-MANHATTAN, INC., Manufacturers of Packings • Asbestos Textiles Mechanical Rubber Products • Abrasive and Diamond Wheels • Rubber Covered Equipment Brake Linings • Brake Blocks • Clutch Facings Fan Belts • Radiator Hose • Powdered Metal Products • Bowling Balls

LINK-BELT ROLLER CHAIN CONVEYORS

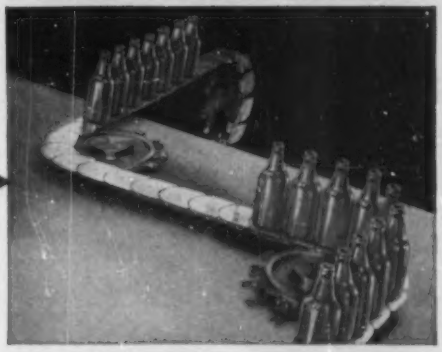
LINK-BELT FLAT-TOP

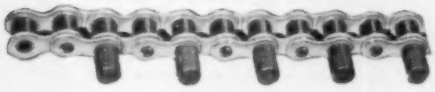
For handling bottles, jars and cans through cleaning, filling, capping and labeling operations. The chain, through its freedom of articulation, prevents "humping" as the chain links remain at uniform height. When progress of containers is halted, continued chain travel will not disarrange them.



LINK-BELT UNIVERSAL CARRIER

The flexible adaptability of this chain with its ease of installation and operation in confined places has made it a favorite for bottling and canning operations. Permits sprocket engagement in two planes. In rectangular, semi-circular or irregular paths, or as one long conveyor, instead of using several transfer conveyors with individual driving mechanisms.

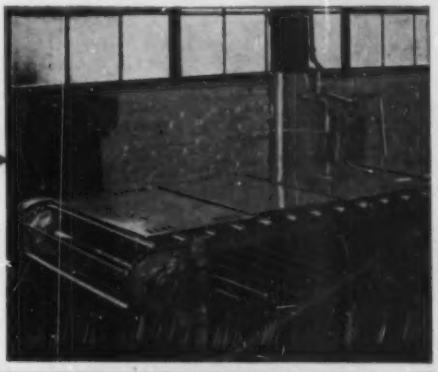




LINK-BELT EXTENDED PIN

Extensively used for timing and conveying purposes. Accurate spacing yet economical arrangement for mounting tubing or special flights between two parallel chains. Available for standard and extended pitch chains.

11,700



LINK-BELT COMPANY Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Houston 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8. Offices in Principal Cities.

LINK-BELT

ROLLER CHAINS & SPROCKETS

World's largest makers of Chains for Power Transmission and Conveying

EVERYTHING IN
Small Tubing
TO DO A PRECISION JOB
½" O.D. to 0.010" Seamless
Non-Ferrous Tubing
Tubing for mechanical pencils, antennas, instrument pointers, Bourdon gauges, or preformed tubing are our regular "run of mill" jobs. However, we draw with equal ease and precision, the more difficult alloys such as phosphor-bronze, nickel-silver, cupro-nickel, nickel and nickel alloys.
A wide range of shapes and alloys . . . temper requirements fulfilled with continuous hydrogen atmosphere annealing furnaces . . . tolerances and finishes to meet your specifications —these are a few of the qualities of Precision drawn tubing.
Whether your designs and plans call for tubing as small as a hair or one-half an inch in diameter—0.500" to 0.010" outside diameter, wall thicknesses down to 0.0015"—you can rely on Precision for finish, accuracy and quick deliveries. That's why design engineers from coast to coast say, "When precision counts, you can count on Precision Tubing." Write today for complete catalog to Precision Tube Company, Inc., Dept. 3, 3824 Terrace St., Philadelphia 28.
WHEN PRECISION COUNTS . . . COUNT ON PRECISION
PRECISION TUBE COMPANY, INC.

"designed right—in the right plastic"

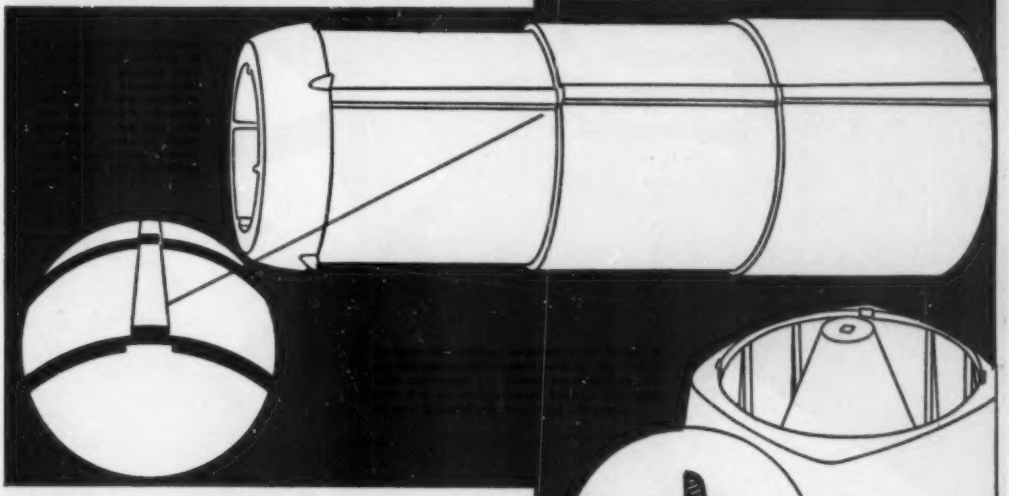
CUSTOM MOLDERS' KNOW-HOW plus

STYRON

solves another production problem!

ANOTHER CUSTOM MOLDING CASE HISTORY

Styron was utilized ingeniously by the custom molder in mass producing this Lily Cup Dispenser. Telescopic dispenser descends slowly into base as cups are removed from top. The choice of Styron for this dispenser meant: lower material and finishing costs, faster assembly and more attractive appearance than any of the materials used previously.



Molded by MacDonald Manufacturing Company for Lily Tulip Corp., New York

The custom molder is skilled in solving difficult fabrication problems in plastics. To serve you, he maintains extensive design and engineering facilities, staffed by technicians with long experience in engineering plastics into finished products. These men have an intimate knowledge of the properties and the performances to be expected from Styron plastic formulations. Their judicious selection of the correct formulation means your product will be "designed right—in the right plastic".

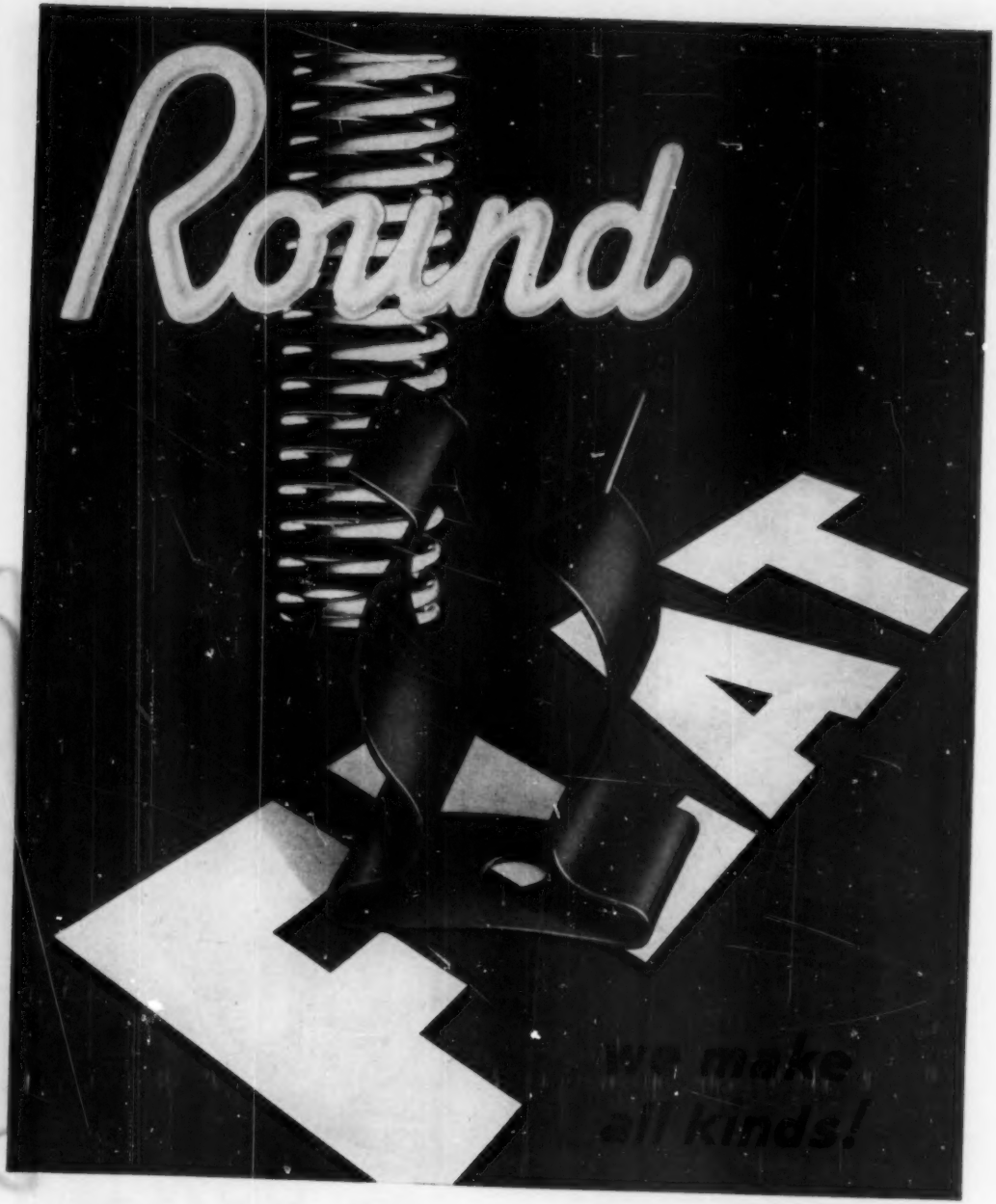
The Dow Chemical Company works with custom molders to help you utilize Styron (Dow polystyrene) to the best advantage in your products. Write Dow today and let us put you in touch with qualified Custom Molders, who can solve your problem.

Plastics Division, Dept. SOT-11

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

New York • Boston • Philadelphia • Washington • Atlanta • Cleveland • Detroit • Chicago • St. Louis • Houston • San Francisco • Los Angeles • Seattle • Dow Chemical of Canada, Limited, Toronto, Canada

DOW



Wallace Barnes Springs

Bristol Connecticut

"Are you telling Me that I don't know how to Count?"

—exploded the chief engineer

NO *SIR*, chief — not *you!* Only meant to suggest that your swell new machine might do itself much prouder, saleswise, if it only — so to speak — could "learn to count." That's all.

But that's a lot! Many machines that have been "taught to count" . . . with a Veeder-Root Counter built-in as original equipment . . . have shown some startling sales-spurts. For this unique feature gives any product a new usefulness, a new sales appeal, a new distinction from competition. And there *are* golden probabilities that *your own product* has hidden talents in functional service which a built-in Veeder-Root Counter can build up into something big. Such talents may hide themselves from you . . . but not from the creative, mathematical eye of a Counting House engineer. He'll be glad to take a look, any time you say.

NEW GENERAL-PURPOSE COUNTER is modern, streamlined, compact . . . fits readily into most design-limits. Attractive to look at, easy to read. Send for 8-page Condensed Catalog and complete spec-sheet on this counter, No. 1260. Write to

Veeder-Root COUNTERS

VEEDER-ROOT INC., HARTFORD 2, CONNECTICUT

In Canada: Veeder-Root of Canada, Ltd., 955 St. James Street, Montreal 3. *In Great Britain:* Veeder-Root Ltd., Kilspindie Road, Dundee, Scotland.

Designer's

4 WAYS TO MEASURE MACHINE SPEEDS

(AND PROTECT PRODUCT QUALITY, CUT MAINTENANCE TIME!)

1 Hand

Check your machine output in jig time by using this General Electric hand tachometer to measure cutting speeds of lathes and milling machines, as well as linear speeds of planer beds, shapers and band saws. Accurate to ±1 per cent, it measures rotational speeds from 200 to 10,000 rpm (with accessories, 20 to 100,000 rpm), and linear speeds from 20 to 10,000 fpm. **See Bulletin GEC-241.**

2 Electric

Protect product quality that might be harmed by changes in machine speed with a G-E electric tachometer equipment. Available types can measure rotational speeds in many ranges, from 0–10 up to 15,000 rpm. Tachometer-generators may be mounted directly on or belted to the shaft being measured. A wide variety of instruments, calibrated in rpm, is available to indicate or record the voltages produced. **See Bulletin GFA-4324.**

GE Tachometers

3 Electronic

Where high accuracy is a "must," use a General Electric electronic tachometer. With either a phototube or tachometer-generator for input signals, it gives you accuracies as high as 0.1 per cent—keeps tabs on frequency, and on rotating, oscillating or translating speeds over a range of 0 to 60,000 rpm. **See Bulletin GEC-224.**

4 Special

For out-of-the-ordinary measurement involving extremely high speeds and accuracies, use a General Electric precision counter tachometer. Exceptional range (500 to 400,000 rpm) and accuracy (±0.025 per cent) makes it ideal for testing efficiency of high-speed machines like turbines and compressors—to save fuel cost, cut maintenance time. Included are speed pick-up, electronic unit, and indicator (illustrated). **See Bulletin GEC-560.**

GENERAL ELECTRIC

Digest PRODUCT HIGHLIGHTS

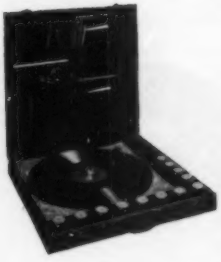
WHEN A PROCESS NEEDS A PUSH

Here's a simple, efficient unit for operating clutches, brakes, levers and valves—the General Electric Thrustor. Smoothly and dependably, it produces a straight-line push through a given stroke, replaces treadle mechanisms, decreases operator fatigue, ups production. Adaptable to remote or automatic control, it's uniform in action, ideal for repeat-operation uses. Available in 10 standard models (largest one shown) producing 50 to 800 lb thrusts, in 2- to 16-inch strokes. **See Bulletin GEA-1614.**

PUT ON THE HEAT —*electrically*

If a machine or process needs a "spot" or "zone" of heat here and there, why become involved in complicated piping and expensive equipment? Simply specify the right type of G-E electric heater for clean, convenient, easily-controlled heat. The broad range includes immersion, strip, cartridge, tubular, fin, cable and unit heaters. A comprehensive 64-page booklet gives you complete data on each type, including applications, features, dimensions and prices. **Ask for Bulletin GEC-1005.**

INDUSTRIAL ELECTRONICS —*explained visually*



Because of the many new opportunities it opens up for product improvement, electronics is almost "must" knowledge for designers today. To provide a quick but thorough grasp of the subject, General Electric offers a visual training course in industrial electronics. It covers practical applications such as relay systems, d-c motor control, rectifiers, etc. Complete with durable case, the kit includes 12 half-hour slidefilms, review booklets, and an instructor's manual. **See Bulletin GEA-5339.**

It's new! It's a beauty! It belongs on your machine!

Single-Phase Capacitor Motor

Where customer eye appeal counts in the equipment you make—in various compressor drives, in water pumps, in small shop and home machine tools, in farm equipment—build in General Electric's new Tri-Clad single-phase capacitor motor. Streamlined for looks, it has these four big features:

Compact build and lighter weight—to save space and shipping costs. In this Type KCS motor, outside capacitor housing and conduit box are eliminated. New motor is 15 to 20 per cent lighter than the old.

Dependable new transfer mechanism—for smooth steady starts. Totally enclosed transfer switch protects contacts from foreign matter.

Long-life ball bearings—to reduce upkeep. Grease chamber is easily filled through a grease-gun fitting in the end shield.

Easy-to-wire terminals—to cut installation time. All connections are on one easy-to-get-at terminal board inside the end shield.

Ratings (½ to 5 hp), frame sizes, mounting dimensions and shaft heights all follow NEMA standards. **See Bulletin GEA-5401.**

General Electric Company, Section C668-77
Apparatus Department, Schenectady 5, N. Y.

Please send me the following bulletins:

- ☐ GEA-1614—Thrustors
- ☐ GEA-4324—Electric Tachometers
- ☐ GEA-5339—Industrial Electronics Course
- ☐ GEA-5401—Single-phase Motors
- ☐ GEC-224 —Electronic Tachometers
- ☐ GEC-241 —Hand Tachometers
- ☐ GEC-560 —Precision Counter Tachometer
- ☐ GEC-1005 —Electric Heaters & Heating Devices

CONSULT YOUR McGRAW-HILL ELECTRICAL CATALOG FOR PRODUCT ENGINEERS! You'll find "everything electric" for machinery manufacturers in the General Electric section.

Name .....

Company .....

Street .....

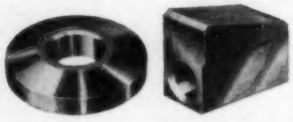
City ..... State .....

THERE'S A GRAMIX GRADE

GRAMIX Parts, Produced From Metal Powders, Eliminate Die Pressed To Tolerances

GRADE 167

For inexpensive, high production, iron parts of any design.



GRADE 249

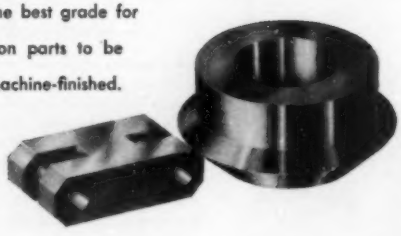
An extra tough grade for parts which need extra strength and wearing properties.

GRADE 273

Nickel Silver — For parts where special corrosion resistance is required.

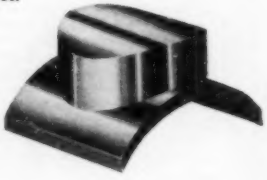
GRADE 266

The best grade for iron parts to be machine-finished.



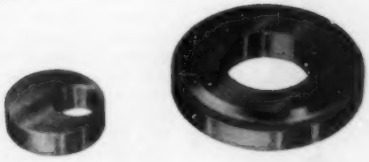
GRADE 277

For certain magnetic parts such as field pieces, solenoids, pole pieces and small transformer cores.



GRADE 41

For heavy, slow-speed bearings of mixed bronze and graphite.



THE UNITED STATES GRAPHITE COMPANY

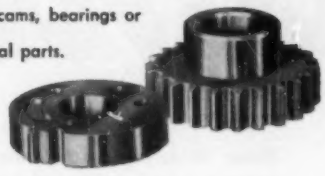
DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

TO FIT PRACTICALLY EVERY DESIGN NEED

Costly Machine Time, Are Self Lubricating, And Can Be As Close As .0005".

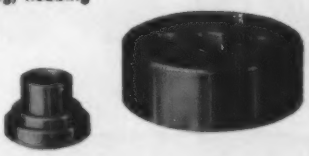
GRADE 86 or 78

For iron parts of great accuracy — gears, cams, bearings or structural parts.



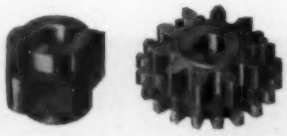
GRADE 61

For bronze parts that require peening, rolling, hobbing or machining.



GRADE 183 BRONZE

— For extra tough bearings where very little oiling is possible.



NON-POROUS GRAMIX GRADES

For seals, pump housings, etc., where non-porous materials are needed.

GRADE 81

For standard bearing installations — highest quality bearing material available.

GRADE 84 or 168

For installations where silent operation is essential.

GRAMIX LEADS THE POWDERED METAL FIELD

THE BIG NAME IN

Redmond

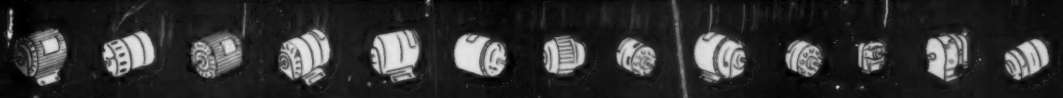
ASSEMBLY LINES HANDLE VARIETY OF MODELS

From these modern Redmond plants come a broad variety of practical Redmond Micromotors and Blowers. Here you get longer-life, smoother-running power units of tested high performance.

Whether the quantities you use are large or small, you get the same personalized service, just as though the Redmond organization were a division of your own

MICROMOTORS ARE INDIVIDUALLY TESTED

ARMATURE WINDING IS STREAMLINED TOO



Over 150 models in 25 types of Series and Shaded Pole Micromotors and Blowers

AC MICROMOTORS FOR REPLACEMENT

Many Redmond customers, not set up to handle replacement motors, appreciate Redmond's replacement motor distributing organization. Approximately fifty of the more diversified AC Micromotor and Blower models best suited for replacement purposes are sold through more than eighty approved outlets located in key cities from coast to coast.

Small Motors

MICROMOTORS

business. And remember this . . . Redmond Company builds no consumer products in competition with your own.

To gain the important benefits of 25 years of progressive electrical engineering and precision manufacturing, to get extra values in sub-fractional electric motors, check with Redmond . . . *the BIG name in Small Motors.*

MILLIONS OF MICROMOTORS ARE BUILT EVERY YEAR

FIELD COILS ARE ACCURATELY WOUND

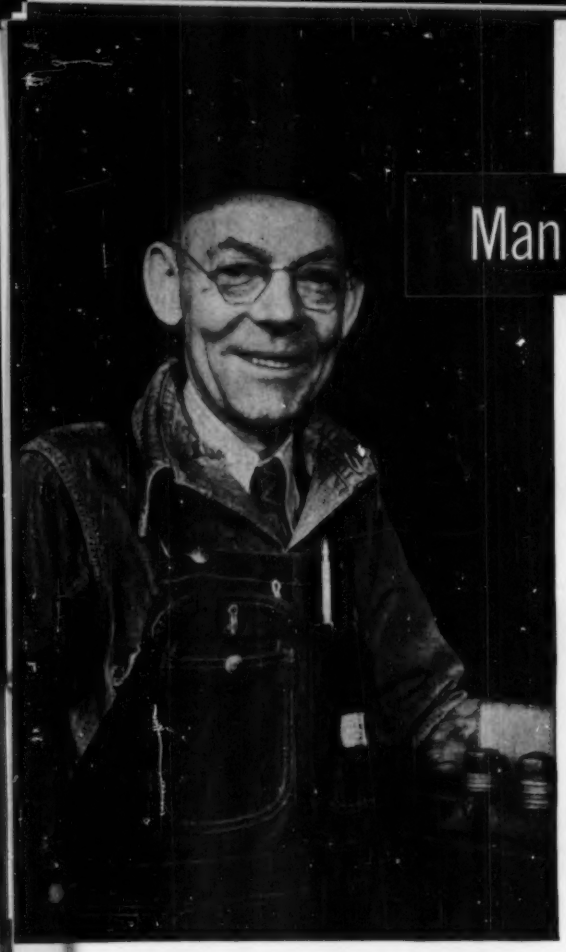
ENGINEERING PROVIDES FINEST DESIGNS

• • Special electrical characteristics, finishes, bolts, accessories, etc., are available

Redmond
COMPANY, INC.
MAIN OFFICES
OWOSSO, MICHIGAN, U. S. A.

INDUCTION MOTOR SALES OFFICES:
EASTERN AREA: 420 Lexington Ave., New York 17, N. Y.
CENTRAL AREA: Owosso, Michigan
MIDWEST AREA: 332 S. Michigan, Chicago 4, Illinois
SOUTHWEST AREA: 1012 N. Industrial Blvd., Dallas 2, Texas
WESTERN AREA: (Redmond Company of Calif., Inc.), 1248 S. Boyle Ave., Los Angeles 23, California
SERIES MOTOR SALES OFFICES: Owosso, Michigan
OVERSEAS SALES OFFICES: 420 Lexington Ave., New York 17, N. Y.

R
REDMOND



Man with 29,999 Brothers

tells why small fabricators like **Shelby Seamless Steel Tubing**

THERE are a number of big reasons why 30,000 small firms use SHELBY Seamless Steel Tubing. As a typical independent operator puts it:

"SHELBY's unvarying high quality, dimensional accuracy, and superior machining characteristics make it easy to fabricate, cut tool costs, reduce rejects, save both time and money, and enable us to turn out much finer workmanship. And, believe me, a small shop has to watch these things if it wants to make money.

"Another important reason for preferring SHELBY Seamless is the wonderful service we get from SHELBY distributors. Now, those people really know mechanical tubing! And, they understand the problems of the small fabricator and seem to appreciate our business. No order is too small to get their prompt and courteous attention.

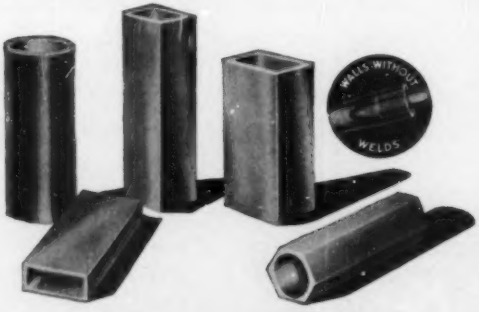
"Is it any wonder, then, that all 30,000 of us 'little fellows' think that SHELBY Seamless is mighty fine tubing?"

You, too, can obtain the same excellent service that has made these thirty thousand small fabricators such satisfied SHELBY users. SHELBY Seamless Steel Tubing is available in round, square, rectangular, and other special shapes in any commercial size—from ⅜ to 10½ OD inches, and in wall thicknesses from .035 inch to 1.500 inch cold drawn . . . and in a wide range of steel grades and anneals.

Know your **Shelby Seamless Distributor** — he knows his tubing and will serve you well!

Shelby Seamless Steel Tubing is available throughout America from a large group of "Gilt-Edge" distributors. There is one convenient to you! He is long experienced in the handling of steel tubing and you can rely on him in all matters concerning mechanical tubing applications. Call on him at any time for prompt, courteous, and efficient service.

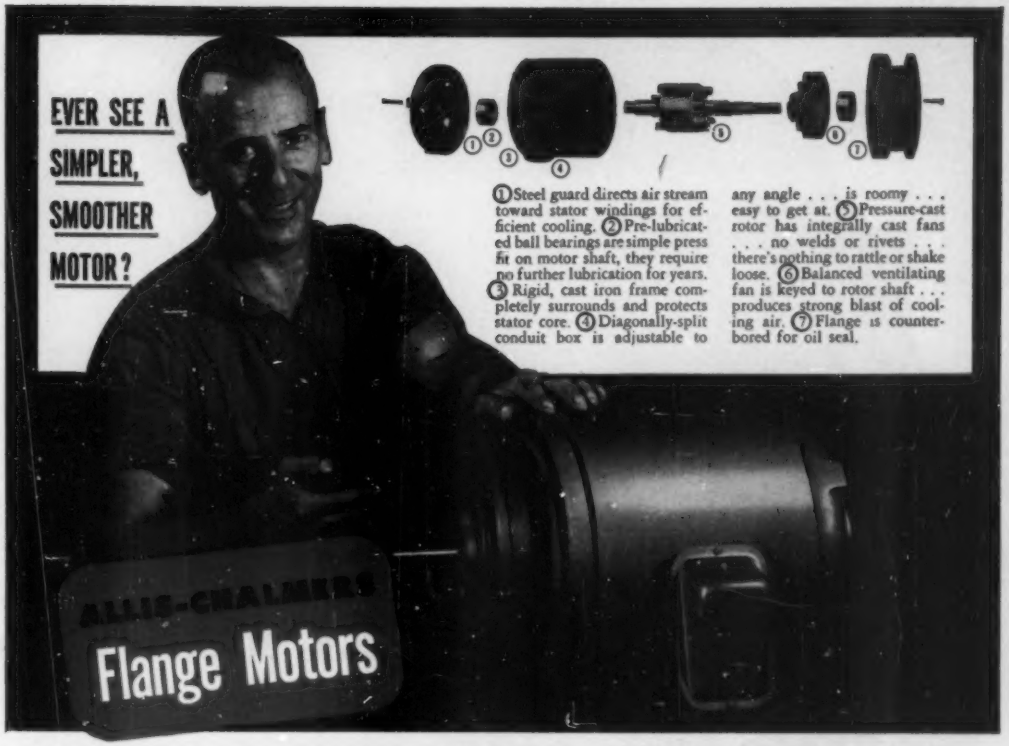
NATIONAL TUBE COMPANY, PITTSBURGH, PA.
(TUBING SPECIALTIES DIVISION)
COLUMBIA STEEL COMPANY, SAN FRANCISCO
PACIFIC COAST DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK



USS

SHELBY SEAMLESS STEEL TUBING

UNITED STATES STEEL



① Steel guard directs air stream toward stator windings for efficient cooling. ② Pre-lubricated ball bearings are simple press fit on motor shaft, they require no further lubrication for years. ③ Rigid, cast iron frame completely surrounds and protects stator core. ④ Diagonally-split conduit box is adjustable to any angle . . . is roomy . . . easy to get at. ⑤ Pressure-cast rotor has integrally cast fans . . . no welds or rivets . . . there's nothing to rattle or shake loose. ⑥ Balanced ventilating fan is keyed to rotor shaft . . . produces strong blast of cooling air. ⑦ Flange is counterbored for oil seal.

. . . meet Designer's Specifications!

CHOOSE *modern* flange motors that are real space savers. These motors "hug-up" tight against your machines . . . help eliminate problems of motor alignment . . . give your product that streamlined appearance that customers like.

And your customers can expect a *new low* motor maintenance from now on! That's because these *improved* Allis-Chalmers flange motors give them this 4-point motor protection:

1. PRELUBRICATED BEARINGS that need no attention for years.
2. RIGID CAST IRON FRAMES that can take hardest abuse.
3. MULTIPLE DIPPED AND BAKED insulation gives extra protection against heat and moisture.
4. ONE-PIECE PRESSURE CAST ROTOR has no rivets or welds . . . there's nothing to shake loose.

Allis-Chalmers Flange Motors are available in C and D flanges and P Bases, sizes to 150 hp. Mail the coupon for specification sheet containing ratings, dimensions, etc.

Whether you need flange motors or any type of motors, remember Allis-Chalmers! Also matching control for *any* motor.

ALLIS-CHALMERS, 1002A SO. 70 ST.
MILWAUKEE, WIS.

Please send me:

- ☐ Flange Motor Specification Sheet (5157324)
- ☐ Handy Guide to Electric Motors (5186052)
- ☐ General Purpose Motor Controls (1487132)

Name .....

Title .....

Company .....

Street .....

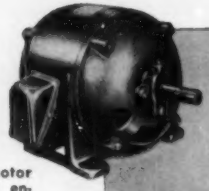
City ..... State .....

A-2918

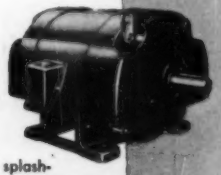
ALLIS-CHALMERS

SOLD — APPLIED — SERVICED BY AUTHORIZED DEALERS, CERTIFIED SERVICE SHOPS, AND DISTRICT OFFICES THROUGHOUT U. S.

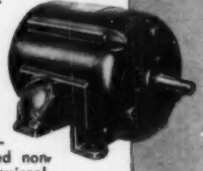
NOW IN MOTORS
IT'S ELLIOTT ALL THE WAY



The BA protected-type motor has drip-proof enclosure.



The BA squirrel-cage splash-proof motor.



The BE totally enclosed non-ventilated squirrel-cage motor.

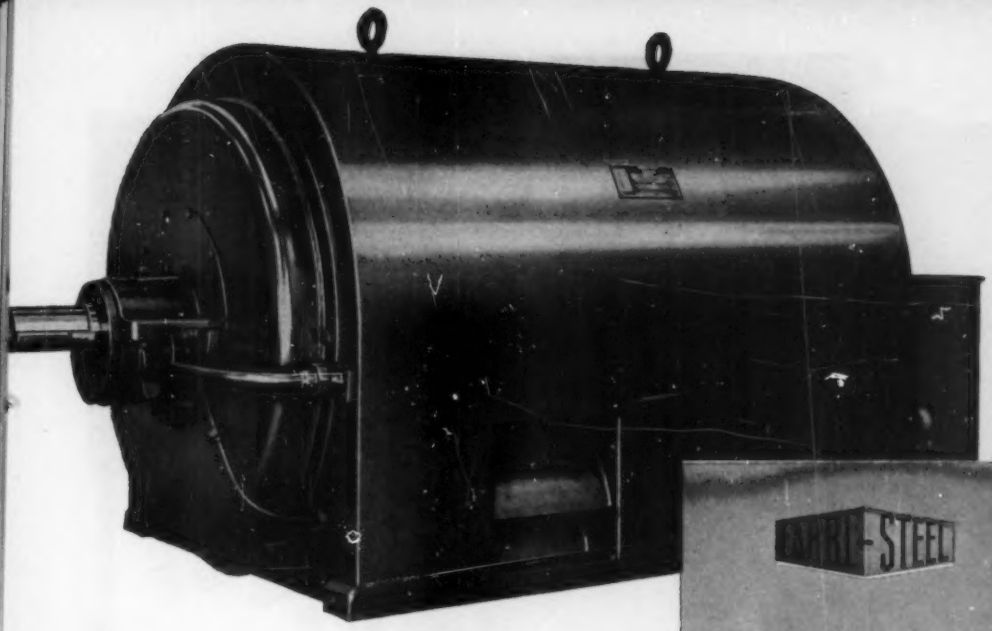
SEALED-POWER totally-enclosed fan-cooled motor (Form CFC).

This soundly established and complete line of motors includes practically every type and variation in small and medium-size motor listings. NEMA specifications and standards are rigidly adhered to.

The motors shown at left are typical C-W products. The BA line, squirrel-cage protected-type, has enclosures suitable for a variety of conditions in which drip-proof and splash-proof constructions are essential. The Form BE motors are totally enclosed, have no ventilating openings, and are cooled by surface radiation. Form CFC are the popular Crocker-Wheeler "Sealedpower" motors, completely enclosed. They are cooled by a constant stream of air blowing across the fins of a distinctive fin-type frame, which has 150% more heat-radiating surface than conventional fan-cooled motors.

For complete data on these and other motor types, write for bulletins.

ELLIOTT COMPANY



FROM 1 hp.-*up*

The Well-known CROCKER-WHEELER line of motors in capacities from 1hp up is now added to the equally popular ELLIOTT "Fabri-Steel" line of large motors in capacities from 250 hp up.

This means that under a single responsibility you can now get any motor you need from the smallest NEMA integral horsepower frame in a wide range of types, to the big, smooth-running all-steel Elliott motor that has made motor history during the past few years, replacing the familiar cast frame and bracket type motors of the past.

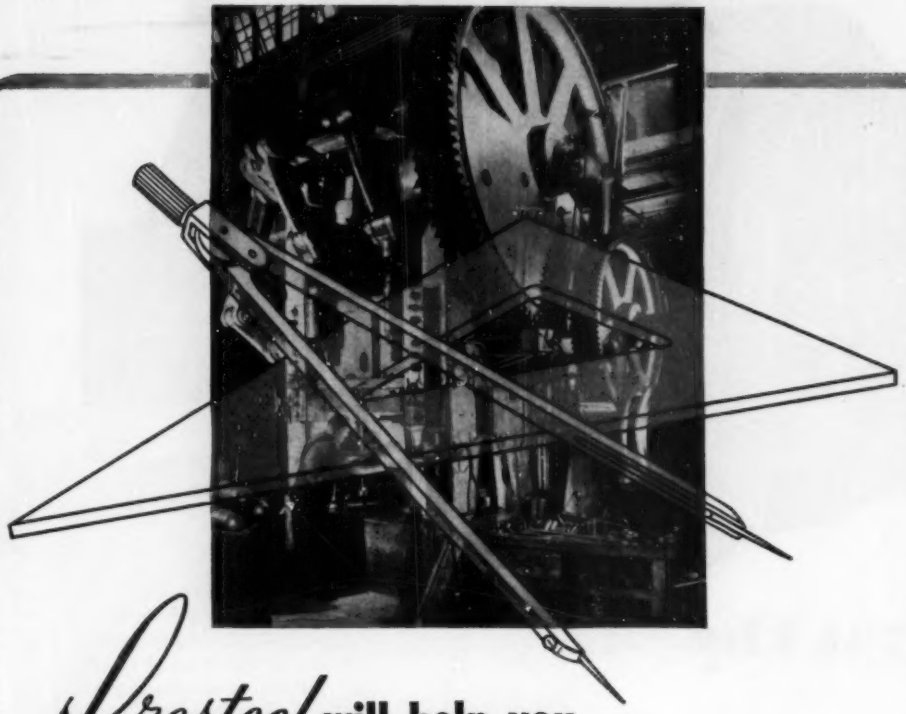
Make your motor problem an Elliott problem—talk it over with an Elliott motor engineer. Informative bulletins on request.

FABRI-STEEL

The all-steel construction of these motors together with a number of other Elliott developments, has set up new high standards of motor performance and operating economy, due to exceptionally rigid strength, general ruggedness and easy maintenance. The FABRI-STEEL two-pole induction motor, illustrated above, is typical of the line. It is available from 250 to 4000 hp, 3600 rpm, in types for normal or high starting torque and low starting current, easily accessible split-sleeve bearings, in various enclosures—drip-proof, splash-proof, enclosed, self- or separately-ventilated and with built-in coolers. The Fabri-Steel line also includes Elliott high-speed induction motors, 4 to 14 pole, 1800 rpm and slower, as well as high- and low-speed synchronous motors designed for specific service requirements, all with similar mechanical design and all-steel construction.

RIDGWAY DIVISION . . . RIDGWAY, PA.
CROCKER-WHEELER DIVISION, AMPERE, N. J.
Plants in JEANNETTE, PA. • RIDGWAY, PA. • AMPERE, N. J. • SPRINGFIELD, OHIO • NEWARK, N. J.
DISTRICT OFFICES IN PRINCIPAL CITIES

E-798



Presteel will help you RE-DESIGN to meet COMPETITION

The manufacturing cost of every metal component part in your product is important. It directly affects your profits. That's why Presteel is constantly re-designing parts for stamping that formerly were fashioned by a more expensive method. Time after time, Presteel stamping engineers have, among other things...

- Reduced the cost per piece
- Reduced production time
- Reduced the number of operations per piece
- Increased part efficiency.

Presteel has the design experience, the expert craftsmanship and the modern plant facilities to help you. Let your nearest Presteel representative talk with you about your component part production. The chances are he will be able to help you save money.

Representatives in DETROIT • BUFFALO
CANTON, OHIO • CHICAGO • DENVER
ALEXANDRIA, VA.

FORT WORTH • INDIANAPOLIS • LOS ANGELES
NEW YORK • PHILADELPHIA • SYRACUSE
TORONTO, CANADA

WORCESTER PRESSED STEEL CO.

702 BARBER AVENUE • WORCESTER 6, MASS.

ALLOY STEEL AND OTHER METALS COLD FASHIONED SINCE 1883

with SYLPHON BELLOWS ASSEMBLIES

SAVE TIME . . . you'll get what you want *when* you want it. We'll meet your production schedules.

SAVE MONEY . . . you'll have less overhead and production costs. Our trained personnel and complete equipment can produce orders in any volume.

SAVE TROUBLE . . . you get assemblies made *exactly* as you want them.

Even if you require a complex bellows assembly—in stainless steel, brass or other metal—we can produce it to your specifications. For that's a specialty with us. We make them for use in practically all industries—*have* been making them for half-a-century. Experience like that is something you can *count* on. If your work is of a confidential nature, we'll cooperate gladly.

Sylphon bellows assemblies have a wide range of uses. For example, in thermostatic devices, pressure controls, hydraulic mechanisms, valves, shaft seals, expansion chambers, recording instruments. There are many other applications.

Find out how they can help you make important savings and improve product performance. Write today. Ask for free Bulletin CP-1200 that gives you complete information.

TEMPERATURE CONTROLS

FULTON SYLPHON
DIVISION
Knoxville 4, Tenn.

Robertshaw-Fulton
BELLOWS ASSEMBLIES • BELLOWS DEVICES

BRIDGEPORT THERMOSTAT
DIVISION
Bridgeport 1, Conn.

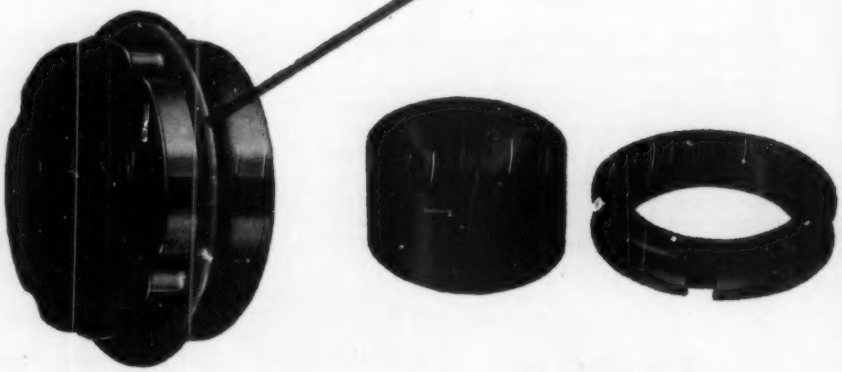
GRAPHITAR

(CARBON GRAPHITE)

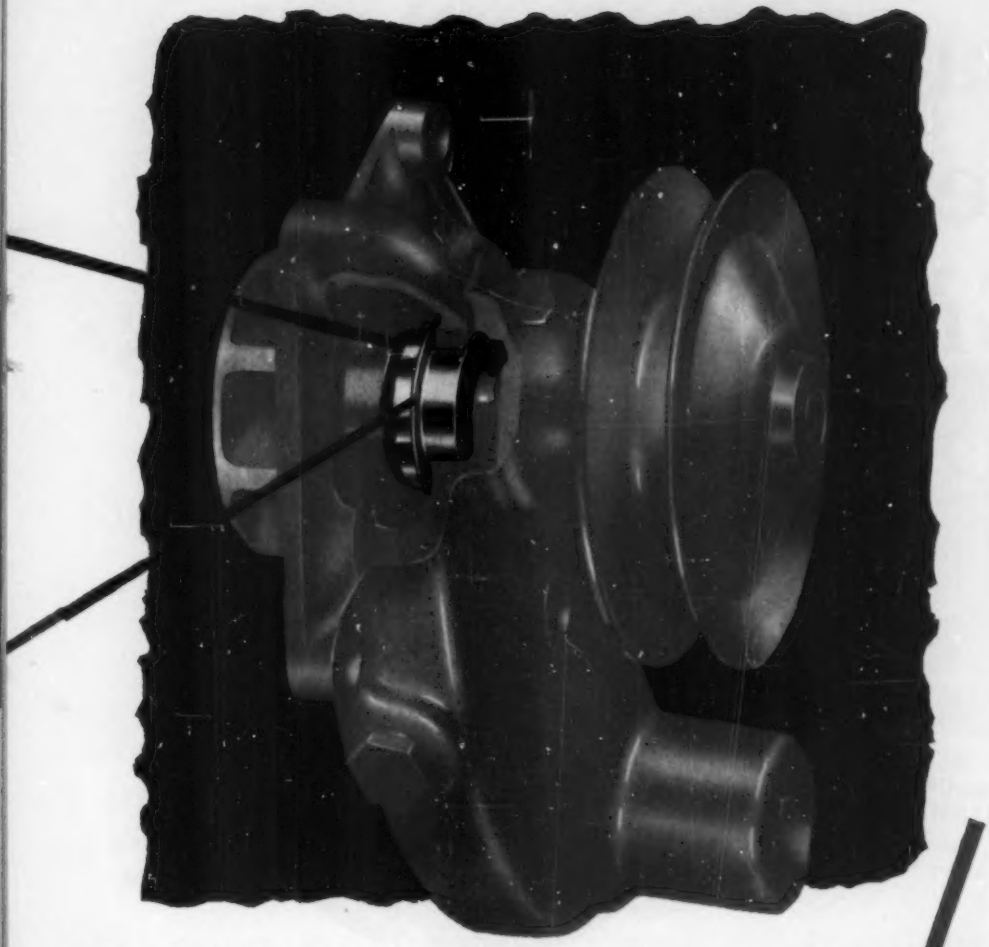
improves performance of automotive water pump

Brummer Manufacturing Corp. of Chicago Heights, Ill. is only one of many automotive parts makers who use Graphitar at vital points in their products . . .

The unique characteristics of Graphitar, the unusual carbon-graphite material, *make it very effective* for seals in a wide variety of liquid pumps. The Brummer Manufacturing Corp. has made Graphitar a standard part of their latest type automotive water pump seals for use in many new automobile models. Graphitar *does not score, seize, or warp* under liquid pump operating conditions. Hot or cold water, alcohol, or any type of anti-freeze cannot leak through a Brummer water pump seal, and the wear resistance and chemical resistance of Graphitar *insure a seal that will last* for the life of the car. Even after long hard use in the pump, the Graphitar unit will continue to form a "good seal."



THE UNITED STATES GRAPHITE COMPANY



GRAPHITAR

(CARBON-GRAPHITE)

Graphitar parts are increasing the efficiency of many products. Because it will not fuse or melt at any temperature, Graphitar makes an excellent seal or bearing at any high-speed heat concentration point. Extremely *light in weight, it is mechanically strong* — in some instances withstanding pressures up to 45,000 psi. Graphitar is chemically inert and remains unharmed on contact with such corrosive acids as hydrochloric and hydrofluoric even in boiling hot concentrated solutions. Graphitar *can be formed according to your specifications* into rings, pistons, seals, bearings, or bushings, any of which can be ground to tolerances as close as .005″ in small sizes. Our engineers will be glad to study your sketches and perhaps suggest ways in which Graphitar will improve the efficiency of your operations. Ask for our new 64 page catalog just released . . .

DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

Eaton Permanent Mold Gray Iron Castings

for DOMESTIC APPLIANCE PARTS

- **Free machinability**
- **Uniform structure throughout the casting**
- **Good tensile strength**
- **Freedom from growth and segregation**
- **Ability to take a high surface finish**

Send for your copy of the illustrated booklet, "A Quick Picture of the Eaton Permanent Mold Process for Producing Gray Iron Castings."

EATON MANUFACTURING COMPANY

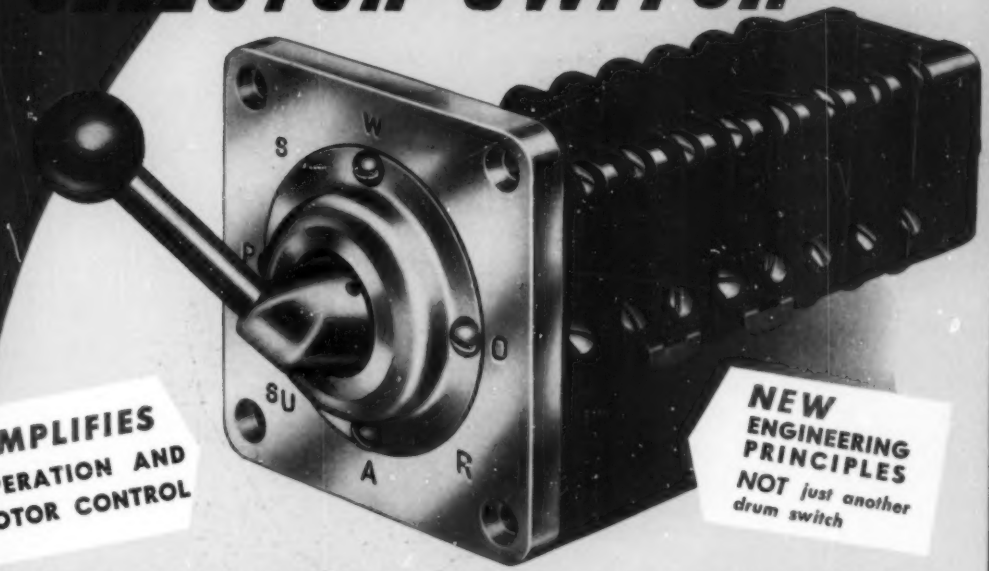
CLEVELAND, OHIO

FOUNDRY DIVISION: 9771 FRENCH ROAD • DETROIT 33, MICHIGAN

PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springtites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

The New PUSH-PULL SELECTOR SWITCH

ARROW AH HART



SIMPLIFIES OPERATION AND MOTOR CONTROL

NEW ENGINEERING PRINCIPLES *NOT just another drum switch*

CUSTOM BUILT TO SUIT YOUR NEEDS, THIS REVOLUTIONARY NEW SWITCH CUTS YOUR CONTROL COSTS, TOO!

The new Arrow-Hart PUSH-PULL-SELECTOR Switch provides a single point of control for a multiple-operation machine. Any combination of momentary contact elements can be arranged — to act in place of push buttons, relays and contactors to start or stop motors. Up to 16 dial positions are available. You can start in any position. You can move from any position on the dial to any other position — without activating any of the intervening operations. Control and load circuits may be combined in as many sections as you require. Each section has 2 completely separate circuits; each can be opened or closed independently in all positions. Any combination required can be used in any position—3-wire or 2-wire control.

SEE PROOF OF THESE STATEMENTS ON NEXT PAGE ▶

CONTROLS and APPARATUS FOR *Outstanding* PERFORMANCE

ARROW AH HART

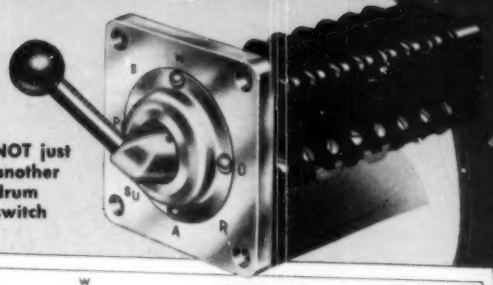
ARROW-HART

103 HAWTHORN ST., HARTFORD 6, CONN., U. S. A.

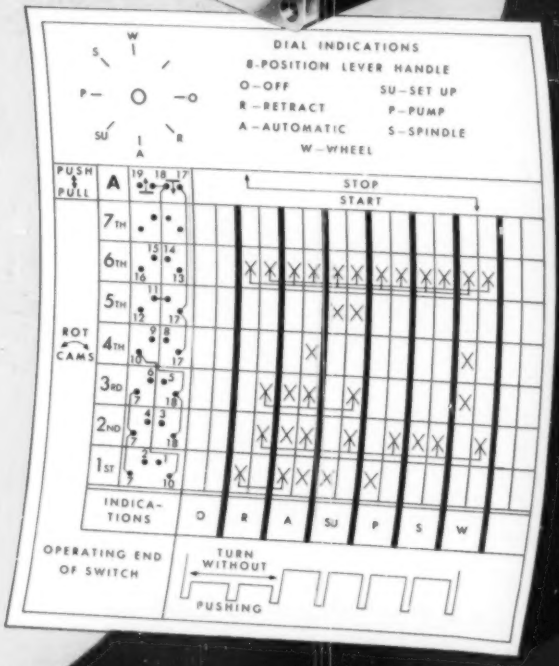
SAVE TIME, MONEY AND SPACE with

The New PUSH-PULL SELECTOR SWITCH

ARROW AH HART



NOT just another drum switch



Arrow-Hart PUSH-PULL-SELECTOR Switches can effect unheard-of savings in your electrical control costs. You save installation and operation time through simple, central control of multiple operations. You save money through lower initial costs and elimination of many components. And you benefit from versatility through the wide selection of circuit-positions. Safe, foolproof operation from one point of control.

The target sheet illustrated at right for the operator's control "PPS" Switch displays the legend and circuit requirements for the New Departure Ball Race Grinder. 2 "PPS" Switches and 3 starters provide complete control. Without the "PPS" Switches control could not have been effected with less than 10 push buttons and 7 starters. Savings in initial costs, installation and operation time speak for themselves!

CUSTOM BUILT TO YOUR SPECIFICATIONS

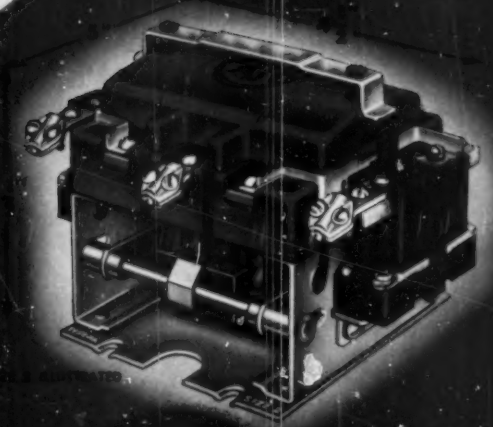
Arrow-Hart PUSH-PULL-SELECTOR Switches are custom built — designed to your individual specifications by Arrow-Hart engineers. The New Departure application of the "PPS" Switch increased production to better than 20%. Similar savings are available to you. Our design, production and assembly facilities are placed at your disposal — to give you the finest in electrical control equipment.

TELL US YOUR CONTROL PROBLEM — give us your requirements — and we'll design a control unit that will give you years of economical, efficient and maintenance-free service. WRITE TODAY FOR "PPS" FOLDER and SPECIFICATIONS SHEETS.

ASK ABOUT THE NEW TYPE "[illegible] MAGNETIC STARTERS

We also offer Conventional Controls

[illegible] feature maximum sight angle balanced operation, longer contact life, Phenlon Alloy head and base. Easy to wire and service. Available in sizes 0, 1, 2 and 3 in local and remote control or enclosed in [illegible] types. Write for literature.



Buy with Confidence
Profit by Performance

ARROW AH HART

Enduring Precision

This spindle bearing is standard equipment on large spindles designed by a world-famous builder of precision grinders. For extreme accuracy, for freedom from vibration, and for enduring precision, only sleeve bearings will do. Where other types of bearing retain their accuracy only for months, Bunting Spindle Bearings endure for years. Where other complex types require a surgical standard of cleanliness and a watchmaker's skill for replacement, the Bunting Sleeve Bearing requires only common-sense and the services of a good mechanic.

The secret of this performance and long life lies in the film type of lubrication. A properly designed and well lubricated sleeve bearing need not acknowledge any superior. No other bearing type possesses its simplicity, its ruggedness, its ability to deliver accurate work for many years. These attributes are possessed by the sleeve bearing.

Bunting engineers are at your service whether your problem is a precision grinder spindle, an aircraft engine, an automobile engine, or something of more or of less exacting requirements. Bunting engineers utilize their extensive experience with bearings of all types in their work of designing Bunting Cast Bronze Sleeve Bearings. The Bunting Brass & Bronze Company, Toledo 9, Ohio. Branches in Principal Cities.

Bunting

BRONZE BEARINGS

PRECISION BRONZE BARS

BUSHINGS

76

Tune in "Suspense!"—CBS Radio Network
Thursdays—CBS Television Tuesdays

DESIGN for better living!

• New beauty, convenience, economy has been made possible through the use of plastics and metal and plastic combinations. The modern automobile has demonstrated this great potential. And the broad scope of the varied applications is being repeated again and again throughout industry.

Here under one roof at Auto-Lite's great Bay Manufacturing Division in Bay City are the technical skills and production capacity for a new art rendered in plastics. The artistic skill of Auto-Lite's Art and Style Division is available on matters of design and development.

THE ELECTRIC AUTO-LITE COMPANY
Bay Manufacturing Division
723 New Center Bldg., Detroit 2, Michigan • Bay City, Michigan

Auto-Lite
plastics and metals

Steel-Weld FABRICATION

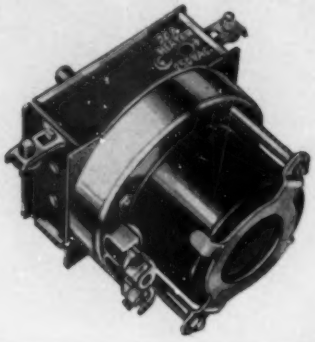
This marine steam engine crankcase and frame is another excellent example of fine workmanship in Steel-Weld Fabrication . . . a job requiring a high degree of accuracy in fabrication, and precision in machining operations . . . it is typical of heavy machinery parts and assemblies produced by Mahon for many customers throughout the country. You, too, will find in the Mahon organization an unusual source for welded steel in any form . . . a source with complete production and machining facilities, backed by a staff of competent design engineers and craftsmen from whom you may expect a smoother, finer appearing job, embodying every advantage of Steel-Weld Fabrication.

THE R. C. MAHON COMPANY
DETROIT 11, MICHIGAN

Engineers and Fabricators of Welded Steel Machine Bases and Frames, and Many Other Welded Steel Products

MAHON

Value Beyond Expectation!



New Mallory Timer Switch

Controls Dual Circuits... With Applications Unlimited!

Mallory creative engineering keeps right in step with the ever-changing needs demanded by product and market evolution... with new and different products designed to improve the operation of equipment for industry and the home.

Typical is the Mallory Model J Timer Switch... based on the same principle that revolutionized the washing machine industry. Originally designed for a clothes-dryer application... controlling the off-on switching of a drive motor *and* a heating element... the Model J is ready for use on almost any two-circuit job. It can be set to operate for 135 minutes for one revolution of the shaft... can be adapted to other time cycles in production quantities. Many manufacturers are finding that its positive action, dependability and unusual versatility surpass their specifications.

That's value beyond expectation!

This switch already is enjoying wide acceptance... perhaps it belongs in your new product. Or if your needs demand another type of special timer switch, let us know. What Mallory has done for others can be done for you!

OUTSTANDING FEATURES OF THE MALLORY MODEL J TIMER SWITCH

- Small size.
- Few parts and simple design.
- Will operate on any commercial frequency and voltage.
- Will handle up to 20 amperes.
- Foolproof operation.
- Approved by Underwriters' Laboratories, Inc.

Television Tuners, Special Switches, Controls and Resistors

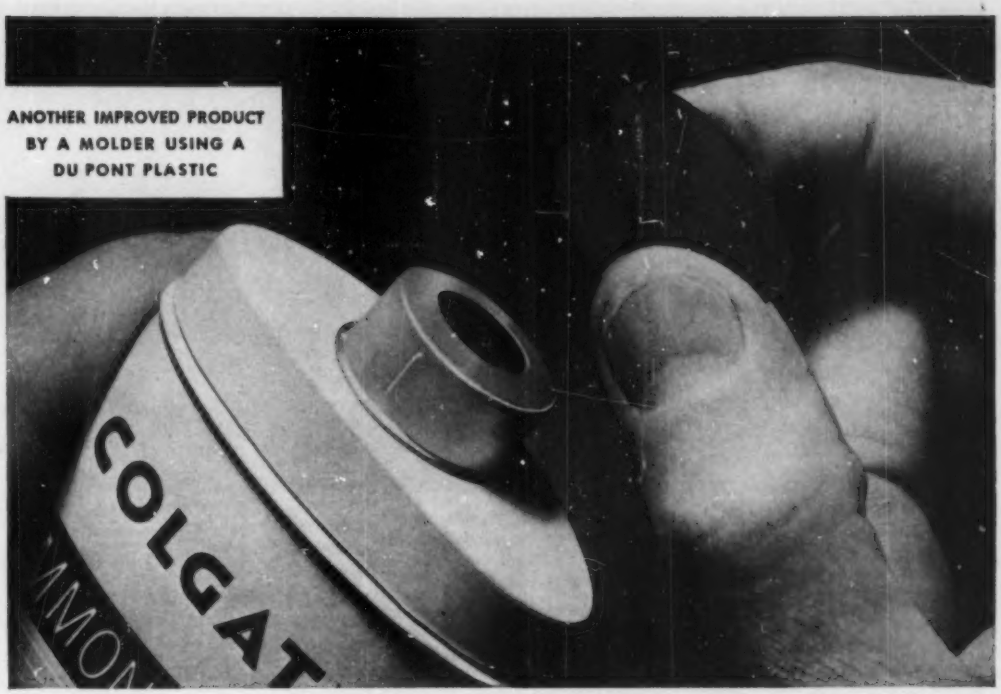
P. R. MALLORY & CO. Inc.

MALLORY

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

SERVING INDUSTRY WITH

Capacitors — Contacts
Controls — Resistors
Rectifiers — Vibrators
Special Switches — Power Supplies
Resistance Welding Materials



TOPS IN TOPS

Low-cost closures of Du Pont polythene fit snugly, are easy to remove, always look their best

THEY look better, perform better, they're economical. That's why Colgate tops off its talcum and ammoniated tooth powder containers with

* * *

WHAT'S NEW. This specially shaped weaning cup of tough Du Pont nylon plastic won't break or chip . . . can be sterilized in boiling water. The strength and resiliency of nylon made possible this unusual molding job in which the top curves into a diameter smaller than that of the body of the tumbler. For this application, only nylon could be molded with such a thin wall and successfully sprung from the mold. (Tumbler designed by Midwest Consultants, Inc., St. Louis; molded and silk-screened by Arnold Brilhart, Ltd., Mineola, N. Y., for Pet Milk Co., St. Louis)

closures of Du Pont polythene plastic. Polythene closures have the resilience to accommodate slight variations in container-top dimensions. Hence they fit snugly, yet permit easy removal. And they don't chip, peel, or become disfigured in use.

Polythene closures are economical. Material cost is low, and the light weight of polythene permits more closures per pound than would be possible with other materials. The need for liners is eliminated because of the snug fit and because polythene is tasteless, odorless, non-toxic, and inert to most packaged ingredients. Too, polythene is available in a wide range of colors, and the ease with which it can be injection-molded permits great versatility of design.

In addition to its variety of uses in the packaging field, polythene has won an important place in the electrical and chemical industries, as well as in a host of consumer items. Maybe you, too, can take advantage of its unusual combination of properties to produce a better product economically. Du Pont representatives will be glad to work with you. Write today for free literature on polythene and other versatile Du Pont plastics.

E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Plastics Sales Offices: 350 Fifth Avenue, New York 1, N. Y.; 7 S. Dearborn Street, Chicago 3, Ill.; 845 E. 60th Street, Los Angeles, Calif.

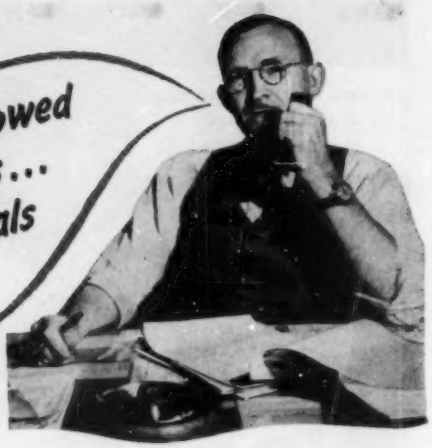
Polythene closures molded by Sameric Engineering Co., Riverdale, N. J., for Colgate-Palmolive-Peet Co.

DU PONT
REG. U.S. PAT. OFF.
Plastics
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

MANNING MAXWELL & MOORE M&M TRADE MARK

Chief Research Engineer Reports on Valve Trim Materials

"S" Monel consistently showed better anti-galling properties... than any of the other metals we have tested...



Albert D. Eplett

These are the words of Albert D. Eplett, chief research engineer of MANNING, MAXWELL & MOORE, INC., Bridgeport, Conn.

As a result of controlled laboratory tests made under his direction over a period of years, "S" Monel* is now standard material for guide sections in four types of Consolidated Safety Valves.

Here Mr. Eplett tells you about one of the actual tests:

"We carried out our anti-galling tests," he says, "by building a small valve identical to the larger ones ordinarily used. We devised a cam-operated mechanism that would give us lifting characteristics similar to those that occur with steam. Superheated air was carried in through the nozzle and up over the disc and guide portions, where we located thermocouples. When galling occurred, a cut-out device shut off the operating mechanism.

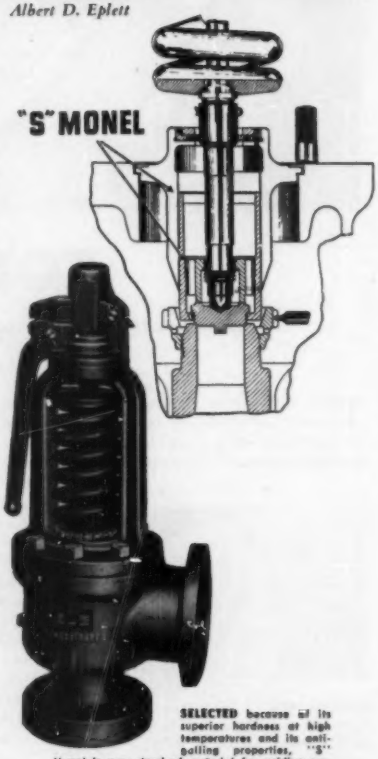
"By this method, we have tested a great number of valve trim materials, including the so-called super alloys. ***And we discovered that "S" Monel consistently showed better anti-galling properties in combinations with other metals and against itself than any of the other metals we have tested*** – excluding, of course, hard facing alloys, which are not as economical to use."

"S" Monel, in addition to its non-galling characteristics, has the well-known properties and advantages of *all* INCO Nickel Alloys. ***It is strong . . . tough . . . fatigue resistant . . . corrosion resistant.*** It simplifies fabrication and offers economies in valve trim for high temperature service; it is an outstandingly efficient material for heat-treated engine castings, hot air scoops, fuel line fittings, pump liners, fuel and oil tank flanges, wing hooks, etc.

DO THIS – NOW

Get more information about extra-hard heat-resistant "S" Monel and other specialized valve materials. Write to R. F. Johnson, c/o The International Nickel Company, and ask him to send you INCO's valuable booklet, ***Trimming Valve Costs with Lasting Trim.*** It tells you how to make valves last longer, whether they handle live steam, hot chemicals, compressed air or corrosive cooling water. Send today for your free copy. A post card will do.

*Reg. U. S. Pat. Off.



SELECTED because of its superior hardness at high temperatures and its anti-galling properties, "S" Monel is now standard material for guiding sections (arrows) in this Manning, Maxwell & Moore Consolidated Safety Valve. Used in the hardened state, the "S" Monel parts cast at Inco's foundry are given a ground finish with an emery cloth polish prior to assembly.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

EMBLEM OF SERVICE
NICKEL INCO ALLOYS
MONEL* • "K" MONEL • "S" MONEL • "R" MONEL • "KR" MONEL
INCONEL* • NICKEL • "L" NICKEL • PERMANICKEL* • DURANICKEL* • INCONEL "X"
*Reg. U.S. Pat. Off.

STERLING INC., Milwaukee, manufacturers of *"Sterlco"* heating specialties and vacuum and condensate return units has used *Electrifugal* pumps for the past 15 years.

According to their President, Paul A. West, *"Electrifugal* pumps are compact, require a lot less space than separate motors and pumps. And, because they don't have to be aligned, they are easier to install. We find that we are able to design smaller overall-size units with these pumps. As for operating dependability, we *know* they stand up under long service. One of our customers operating a dual vacuum pump unit, reports over 12 years of continuous 24-hour-a-day duty cycle operation — no trouble of any sort."

Save Space..Cut Design Costs

WITH THESE ALLIS-CHALMERS PUMPS!

2. COOLANT PUMPS

Foot-mounted, submerged, and side wall mounted types... sizes from 1 in. x ¾ in. to 1½ in. x 1½ in. Unit shown is side wall vertically mounting type — used extensively on broaches, drills, lathes, milling machines. Check coupon for information on complete Allis-Chalmers Coolant Pump line.

3. PEDRIFUGAL PUMPS

Pedestal-type pump that can be direct or *Texrope* V-belt driven for varying capacity and head. Five sizes handle all general pumping requirements to 500 gpm, heads to 110 ft. Pre-lubricated bearings require no further attention for three to five years. Check coupon for more information about *Pedrifugal* pumps.

Texrope, Electrifugal and *Pedrifugal* are Allis-Chalmers Trademarks.

ALLIS-CHALMERS

A-C

ALLIS-CHALMERS, 1002A SO. 70 ST., MILWAUKEE, WIS.

Gentlemen: Please send me information on:

- ☐ Electrifugal Pumps — 5286140A
- ☐ Coolant Pumps — 5286975
- ☐ Pedrifugal Pumps — 5286691

Name

Title

Firm

Address

City State

A-2958

SOLD AND APPLIED BY AUTHORIZED DEALERS, AND DISTRICT OFFICES THROUGHOUT U. S., SERVICED BY CERTIFIED A-C SERVICE SHOPS

A.O.Smith Builds ELECTRIC MOTORS

for hundreds of products, including

PERFECTION VACUUM PUMPS

made by Perfection Manufacturing Corporation, Minneapolis, for locker and packing plant installations of the new

DEWEY and ALMY "CRYOVAC" PACKING PROCESS

This is another example of how the facilities of the A. O. Smith research and engineering staff can help integrate motor design with product design. In this instance, the result is important news, the subject of *Business Week's* Nov. 19 cover story, "Plastic Wraps for Turkeys . . . or Anything."

If you are seeking improved performance in your product, or if you require special characteristics in your power component, consult the A. O. Smith sales engineer. For information on A. O. Smith Electric Motors, send the coupon.

PERFECTION MOTOR VACUUM PUMP in a poultry packing plant "CRYOVAC" installation. The bird is slipped into the "CRYOVAC" plastic bag and air evacuated by vacuum pump. The sealed bag is then given a shower in 190° water. Instantly it shrinks tight around the bird. This process and the "CRYOVAC" bag are developments of Dewey and Almy Chemical Company, Cambridge, Mass.

A. O. SMITH ELECTRIC MOTOR for this unit is ¼ hp, 115/230 V., 60 cycle, 1725 rpm, single phase. Open drip-proof construction; dual rotation.

24-HOUR MOTOR SERVICE

To more than 200 authorized service stations, the A.O. Smith Product Service Division provides fast, low-cost electric-motor service, on a 24-hour, off-the-shelf basis. Factory Service Branches and Warehouses at Union, N. J., Chicago 17, Dallas 2, Los Angeles 12.

Ask the A. O. Smith sales engineer about electric motors for both standard and special uses.

A.O. Smith Corporation, Dept. PE-250
5701 Smithway Street, Los Angeles 22, California

Without obligation, send us full information on A. O. Smith Electric Motors.

Name_____

Firm_____

Street_____

City_____ State_____

76th ANNIVERSARY 1874 - 1950

A.O.Smith

ELECTRIC MOTORS

Boston • New York • Pittsburgh • Cincinnati • Syracuse
Cleveland • Atlanta • Chicago • Minneapolis • Detroit
Milwaukee • Houston • Tulsa • Dallas • Denver • Seattle
Los Angeles • San Francisco
Motor Export Department: 13 East 40th St., New York 16

Some of America's finest refrigerators keep temperatures under close control with Hydron Bellows Assemblies
Will Bellows Assemblies do it better for you?

Many other firms looking for better ways to control temperature or pressure, to seal shafts or valves against leakage, or to transmit motion, have turned to bellows assemblies. Investigation before your designs are too far advanced may pay you, too. Let our engineering department make a confidential analysis of your sketches and specifications and make a recommendation. No obligation, of course.

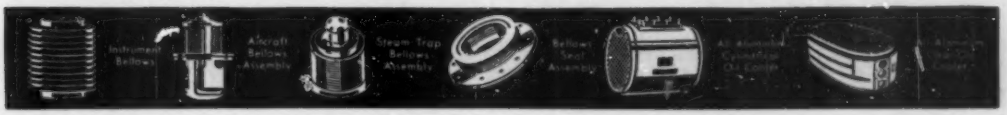
CLIFFORD MANUFACTURING COMPANY, 122 GROVE ST., WALTHAM 54, MASS. *Division of Standard-Thomson Corporation.* Offices in New York, Detroit, Chicago, Los Angeles.

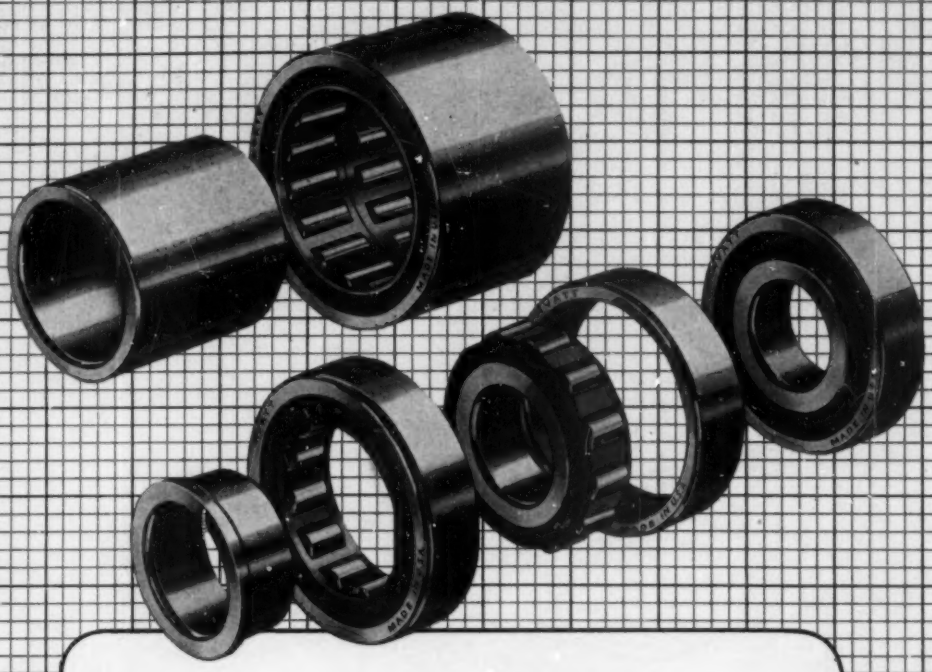
HYDRON

CLIFFORD

HYDRAULICALLY-FORMED BELLOWS AND BELLOWS ASSEMBLIES

ALL-ALUMINUM OIL COOLERS FOR AIRCRAFT ENGINES





Take Advantage of HYATT Experience

Hyatt Hy-Load bearings are high capacity cylindrical roller bearings. They are available in two diameter series, wide and narrow widths and standard AFBMA boundary dimensions.

There are ten major types; four with separable inner races, two with separable outer races and four which are non-separable.

This wide range of available sizes and types, plus complete interchangeability of parts permits wide flexibility of machine design and assembly procedures.

Over the years, more and more design engineers have come to rely upon Hyatt for completely dependable bearing engineering. If bearings are part of the machine you are designing reach for your Hyatt catalog or make use of the Hyatt Engineering Service. For further information write to Hyatt Bearings Division, General Motors Corporation, Harrison, N. J., Chicago, Detroit, Pittsburgh and Oakland, Calif.

HYATT ROLLER BEARINGS

Makes everyone's job easier!

PARKER-KALON

SIZE-MARKED

Socket Head Cap Screws

Tool crib bosses

like 'em because the Size-Mark speeds up sorting of left-over, mixed screws, without the bother of "miking" or gauging.

Assembly workers

welcome them because the Size-Mark speeds the job. Sizes are always issued correctly — there's no time wasted, no annoyance.

Apprentices

are all for them because the Size-Mark saves time, protects "green hands" from errors, helps them learn faster.

and that GEAR GRIP† makes 'em slip-proof!

† U. S. DESIGN PAT. NO. 156,410

Even when fingers are oily, the GEAR GRIP on P-K* Socket Head Cap Screws prevents slipping. When fingers can fly, the work flies!

Only Parker-Kalon offers the SIZE-MARK and GEAR GRIP. Take advantage of these exclusive features—watch your product's assembly costs go down, its sales appeal go up.

SEND FOR SAMPLES and Stock List. Simply address Parker-Kalon Corporation, 200 Varick St., New York 14, N. Y.

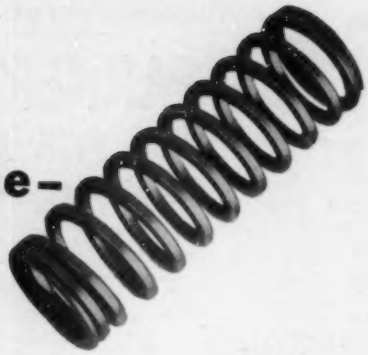
P-K PARKER-KALON* *cold-forged* SOCKET SCREWS

SIZE-MARKED SOCKET HEAD CAP SCREWS • GROUND THREAD SOCKET SET SCREWS
FLAT HEAD SOCKET CAP SCREWS • STRIPPER BOLTS • PIPE PLUGS • HEX KEYS

AVAILABLE EVERYWHERE THROUGH ACCREDITED DISTRIBUTORS

*REG. U. S. PAT. OFF.

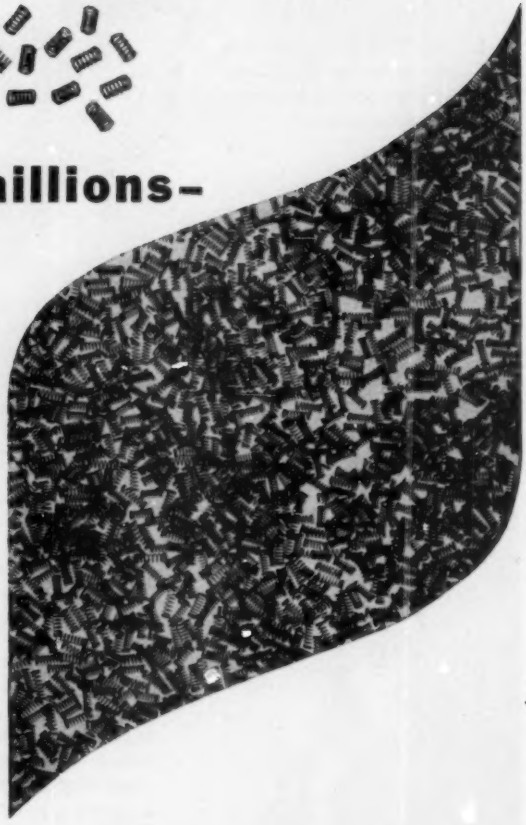
A small spring–



or a large one–

a dozen–

or millions–



"BIG PLANT" service—with "small order" facilities—makes it easy for you to buy from *one source* any type of spring, small stamping or wire form you may need, in any quantity, from any material. Use Gibson spring skill to contribute to spring quality . . . and economy. Let us quote, with samples if desired, from your blueprints or project specifications.

SMOOTH ACTING

GIBSON-SPRINGS

CLIPS · SMALL STAMPINGS
CLAMPS · WIRE FORMS

The William D. Gibson Co.

DIVISION OF ASSOCIATED SPRING CORP.

1800 CLYBOURN AVE. CHICAGO 14, ILL.

YOU CAN BE **SURE**.. IF IT'S

Westinghouse

HOW LONG

will the Life-Line bearing last?

As long as comparable periodically lubricated bearings—or longer!

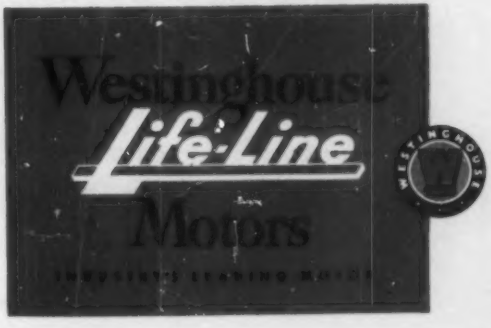
BEARING MANUFACTURERS SAY: "Pre-lubricated bearings have the same life expectancy as periodically lubricated bearings *IF those periodically lubricated bearings are perfectly maintained.*" But how often is a bearing perfectly maintained? Not often enough! That's why Life-Line pre-lubricated bearings offer fewer motor outages due to lubrication faults.

OPERATING RECORDS SAY: "41% fewer failures with Life-Line pre-lubricated bearings!" Life-Line motors placed in service throughout industry show a record of 41% fewer bearing failures than the best conventional motor (with conventional bearings) ever built by Westinghouse!

USERS SAY: "Life-Line bearings save me money." One motor user reports yearly lubrication costs of $3.06 per motor on ordinary motor bearings. An industry average indicates a yearly cost of $2.70 per motor a year. Multiply this by the hundreds of motors in your plant and you'll see why pre-lubricated Life-Line offers you an opportunity to cut life costs of motors. Life-Line needs no lubrication. You save this cost.

Get all the facts on Life-Line motors. See for yourself how much you can save. Ask your Westinghouse salesman for copies of "Facts on Pre-Lubricated Bearings," (B-4378) and "Motor Costs" (B-4321), or write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pa.

J-21585



A wide range of sizes for an ever-expanding field of applications.

HEIM

Unibal SPHERICAL BEARINGS • SPHERICAL BEARING ROD ENDS • ROLLER BEARINGS SELF ALIGNING BALL BEARINGS • PILLOW BLOCKS • ROLLER BEARING AND BALL BEARING FLANGE UNITS.

UNIBAL SPHERICAL BEARING

The Unibal Spherical Bearing is a really amazing bearing principle employing a single ball bored to fit shafts from .1250 to 1.875. Diameters of bearing housings from .469 to 4.000

MALE & FEMALE

ROD ENDS

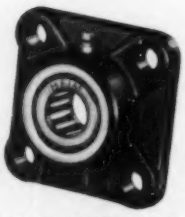
FLANGED ROLLER BEARING

There is a HEIM bearing to meet YOUR requirements.

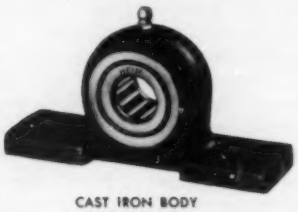
Please write for complete catalog

FLANGED BALL BEARING

BALL & ROLLER BEARING PILLOW BLOCKS



BALL & ROLLER BEARING FLANGE UNIT

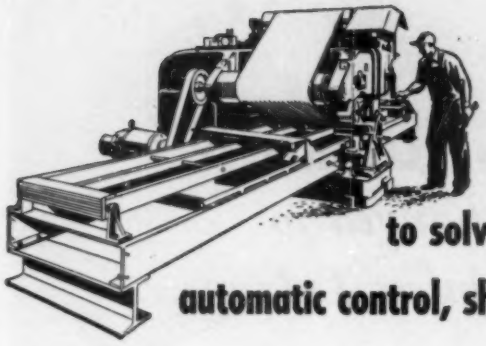


CAST IRON BODY PILLOW BLOCKS

HEIM

THE HEIM COMPANY

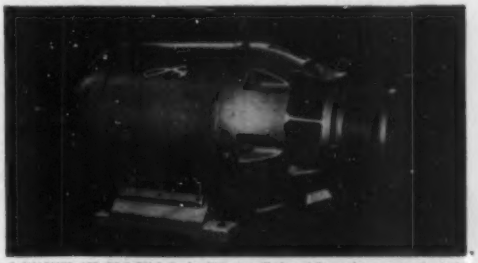
FAIRFIELD, CONNECTICUT



Smart design engineers use WARNER ICB UNITS to solve problems of clutching, braking, automatic control, shock and torque on their products

IF YOUR PROBLEM

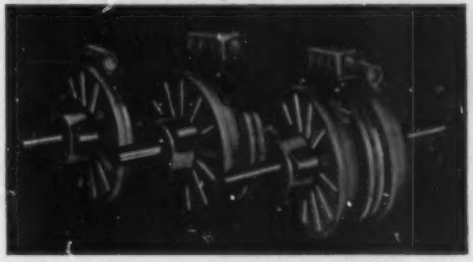
is to design your machine or its activating parts so that *you get:* (1) Push-button actuation at the machine or a remote control panel. (2) Fully or semi-automatic operation in "stop" or "start" of machine cycles. (3) Controlled acceleration or deceleration. (4) Automatic or manual adjustment of torque to load . . . or if your problem is *to eliminate:* (1) "Shock" from stop or start on gear trains and shafts. (2) Complex mechanical lever linkage, or air and hydraulic piping systems. (3) Vibration and hammering from solenoid operated brakes and clutches . . . or if you want to *increase production* from your machine by increasing the speed and number of cycle operations —



A WARNER ICB 9" x 2½" Brake Unit installed and housed on a standard 40 hp motor for a flat belt sander. Installation speeded up machine cycling, gave better, faster operational control. Installation is simple, compact and readily accessible.

A GOOD SOLUTION

to any one or combination of these problems is WARNER ICB Units. WARNER ICB Units are electrically controlled and operated clutches and brakes. They are compact, mechanically simple and may be applied to machine spindles, drive shafts, or direct to electric motors. Because of their design, they may be operated individually or in combination, manually or automatically, by direct or remote control. They provide for infinite controlled variation of torque in either clutching or braking action within their rated capacities. Their action is smooth and shockless—fast and practically noiseless. They are self-adjusting and self-compensating for life. Their design guarantees a high rate of heat dissipation.



From left to right: a Warner ICB Brake Unit, a Warner ICB Clutch Unit, and a combination Warner ICB Clutch and Brake Unit. Note clean, smooth, compact, appearance — simple mechanical parts.

MORE INFORMATION

on WARNER ICB Units and their application as clutches or brakes to various kinds of machinery is available. They may be used on continuous or intermittently operated machines. There is a complete range of sizes to meet both braking and clutching torque needs. If you have a design problem such as indicated above, write today for our free bulletin No. 701. If possible, state your problem. Not only will you receive your bulletin copy, but experienced WARNER ICB engineers will be glad to consult with you without obligation. Write direct to WARNER ELECTRIC BRAKE MANUFACTURING COMPANY, Beloit, Wis.

Bulletin 701 contains complete specifications and description of WARNER ICB Units. See for yourself how they offer advantages never before available on industrial clutches and brakes. Write for it today — no charge.

WARNER
ICB UNIT

WARNER ICB Units are manufactured by Warner Electric Brake Mfg. Co. — pioneers in the field of electric brake design and application since 1927.

6 OPERATIONS ELIMINATED

when they changed to Carpenter Stainless Tubing...

This job is exceptional, but it shows what *can* happen to unit costs when you make use of Carpenter's experience with Stainless Tubing.

Unit costs were way out of line and rejects were piling up on the floor when this water cooler part was made from sheet. Seven operations were required on each part. Silver soldering of finished units was practically impossible because the fabricated material would not satisfactorily withstand high temperatures.

Now, water cooler parts are fabricated in one reverse bending operation from Type 304 Carpenter Stainless Tubing. Six operations, ranging from the slitting of sheet to the annealing of fabricated parts, have been eliminated and the soldering of assemblies is a snap.

To find ways to save time and reduce unit costs on your own jobs, put our Stainless Tubing experience to work. It will cost you nothing and may save you plenty.

Sanitary parts for water coolers cost less to make now that Carpenter Stainless Tubing is used to provide the durability that reduces servicing costs.

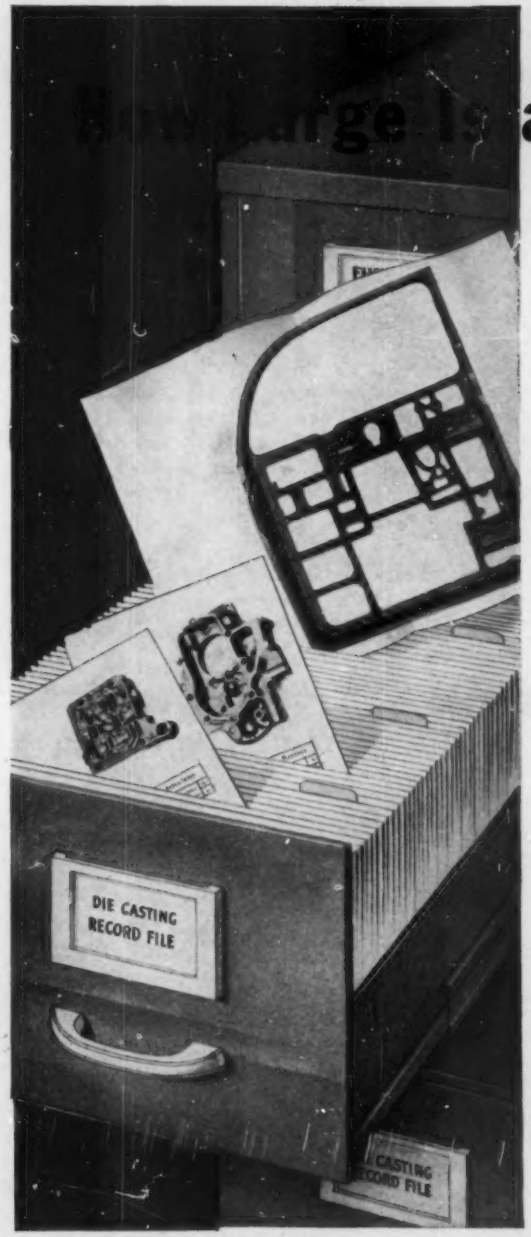
THE CARPENTER STEEL CO.
Alloy Tube Division • 121 Springfield Road • Union, N. J.

NEW FILE FOLDER OF DATA ABOUT STAINLESS TUBING

For useful information about physical properties, heat resistance characteristics, standard sizes, etc., write on your company letterhead and ask for the 12-page Carpenter Stainless Tubing Data File Folder.

24-Hour Service On Your Orders...
You get definite delivery information within 24 hours when you call your Carpenter Stainless Tubing Distributor.

Carpenter
STAINLESS TUBING
"MORE THAN CORROSION RESISTANCE"



How Large Is a Die Casting?

?

This question has been asked frequently since our last achievement of die-casting automobile door-panels. In size this die casting is forty-three inches high; thirty-three inches wide.

So far, it is the largest aluminum die casting produced.

There is no limit within reason

New vistas ahead are as limitless as the designer dares to imagine. Our engineering and research departments are anxious to cooperate to make your imagination a reality. A phone call to one of our plants, located nearest to you, will bring immediate response.

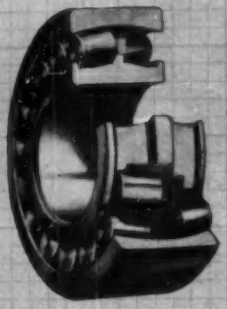
DOEHLER-JARVIS CORPORATION

The World's Largest Producer and Finisher of Die Castings

PLANTS AT: TOLEDO, OHIO · POTTSTOWN, PA. · BATAVIA, N. Y. · GRAND RAPIDS, MICH. · CHICAGO, ILL.

EXECUTIVE OFFICES: 386 FOURTH AVENUE, NEW YORK 16, N. Y.

More Power to Lima-Hamilton Power Shovels ...through TORRINGTON SPHERICAL ROLLER BEARINGS



On the power take-off shaft of its shovels, Lima-Hamilton Corporation uses Torrington Spherical Roller Bearings to transmit power smoothly with minimum friction loss and wear.

Under shock loads, barrel-shaped rollers align themselves freely in the spherical outer race . . . can't bind or drag. Even load distribution is secured without alignment adjustments, and maintained under deflection.

Maximum life expectancy results from this combination of self-alignment with tremendous load capacity in Torrington Spherical Roller Bearings. Secure these advantages in your heavy-duty equipment—our engineers will be glad to help.

THE TORRINGTON COMPANY

South Bend 21, Ind. • Torrington, Conn.

District Offices and Distributors in Principal Cities of United States and Canada

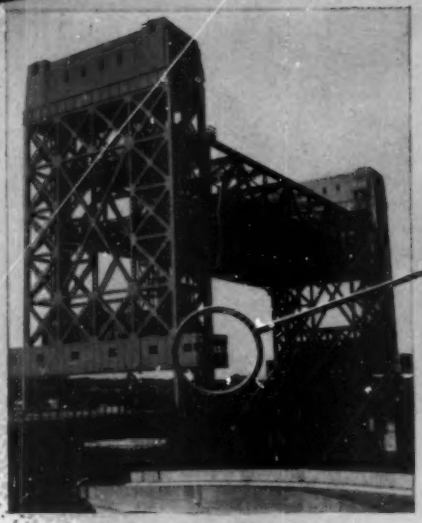
SPHERICAL ROLLER
TAPERED ROLLER
STRAIGHT ROLLER
NEEDLE
BALL
NEEDLE ROLLERS

TORRINGTON *SPHERICAL ROLLER* **BEARINGS**

this job...

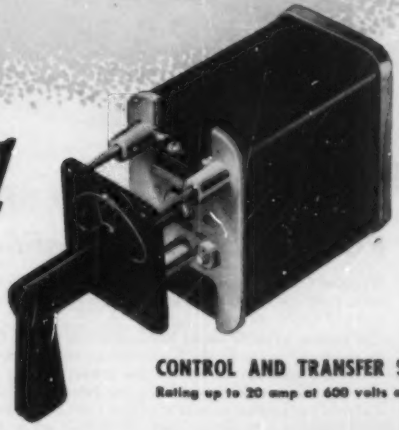
POWER TRANSFER FOR LIFT BRIDGE

STICKEL MEMORIAL BRIDGE, NEW JERSEY STATE HIGHWAY DEPARTMENT, OVER PASSAIC RIVER BETWEEN NEWARK AND HARRISON, NEW JERSEY.



On this 222-foot, 3000-ton span General Electric Type SB-1 control switches are used to transfer operation to the auxiliary power system, select instrument readings, and control the bridge locking mechanism.

..easily done with the SB-1

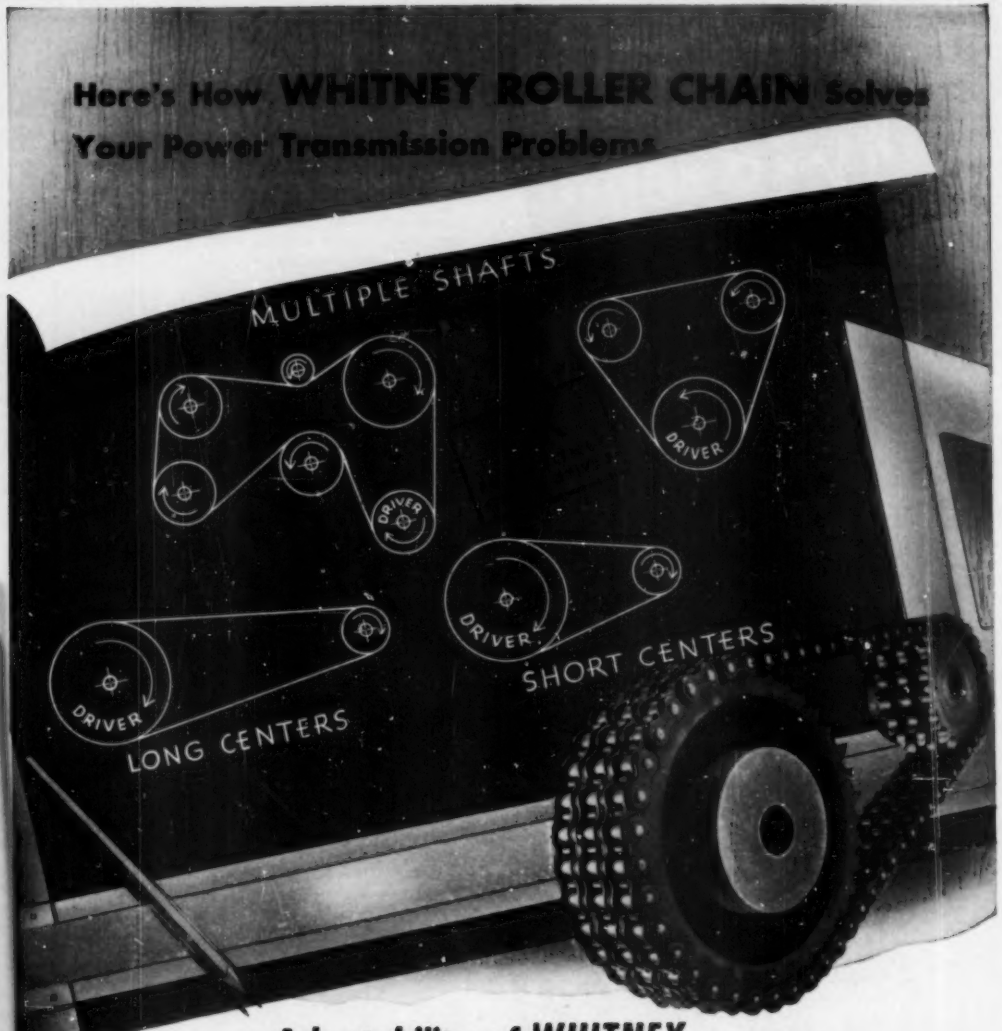


CONTROL AND TRANSFER SWITCH
Rating up to 20 amp at 600 volts a-c or d-c

Standard parts and the simple basic design of the SB-1 mean longer life and low initial cost to you. There's a *standard* SB-1 for most jobs, and they're ready on four weeks' delivery. Easy to order, too. A variety of attractive switch handles, and watertight, dust-tight, oil-immersed, fabricated metal, or explosion-proof housings are available to fit your particular installation problems. Mount on panels ⅛ to 2 inches thick. Switch shown at right is 8¼ inches over-all, 2¾ inches wide, 4¼ inches high. Why not try an SB-1 on your particular control problem? For further details see your G-E sales representative and write for Bulletin GEA-4746. *Apparatus Department, Section 856-71, General Electric Company, Schenectady 5, New York.*

GENERAL ELECTRIC

Here's How WHITNEY ROLLER CHAIN Solves Your Power Transmission Problems



Adaptability of WHITNEY ROLLER CHAINS Simplifies Designs

Whitney Chain drives should be considered as flexible gearing, and, as such, they offer a wide range of drive selection and adaptability to all types of applications.

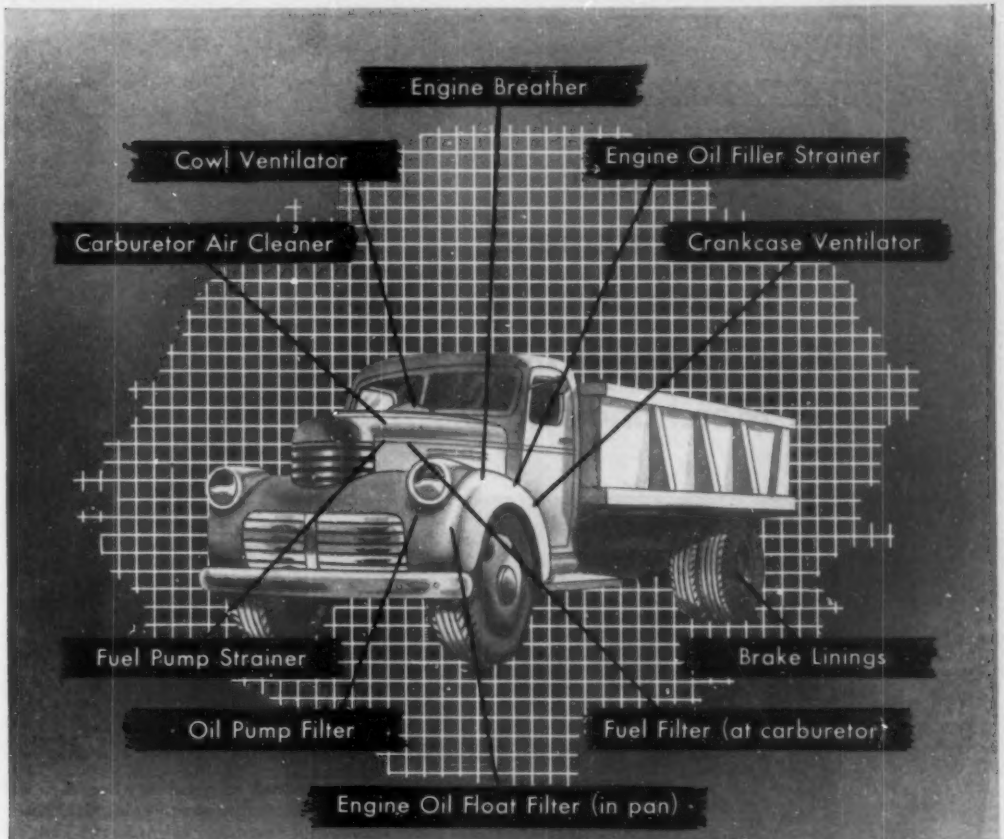
The versatility of Whitney Chain enables you to drive shafts clockwise or counterclockwise all from one power source. These alloy steel Whitney Chain drives deliver *full power* without slippage from power source to driven elements. They can be operated slack on short or long centers. They do not impose excess loads on shaft bearings. They absorb shock and overloads without breakage. They can be put on or taken off without disconnecting shafts or gears.

No matter what your power drive problems Whitney Chains and Cut Tooth Sprockets . . . *the all-steel drives* . . . will meet your requirements. Write for complete details, today.

CHAIN DRIVE IS BETTER

- Positive grip
- Transmits full horsepower
- Simplifies transmission designs
- Low maintenance
- Ease of installation
- Long operating life
- Constant uniform speeds
- High resistance to shock loads
- High load carrying capacity

WHITNEY CHAIN & MFG. CO.
DIVISION OF WHITNEY-MANSON INDUSTRIES, INC.
204 Hamilton Street, Hartford 2, Conn.



wire cloth

FOR THE TRUCK INDUSTRY

Trucks! Indispensable to peacetime industry and agriculture. Vital to America's security. Transportation progress has resulted from the close co-operation given truck manufacturers by progressive parts manufacturers and their research design departments. The Reynolds Wire Company has achieved a reputation for top quality among these parts manufacturers. Through uniformly excellent performance of Reynolds Wire Cloth these automotive vehicles have hauled tons and tons of payload millions of miles, both on and off the highways. Look to Reynolds Wire for added refinements and improvements to meet your specifications and needs. Reynolds 50 years of engineering know how is at your disposal.

REYNOLDS WIRE COMPANY
DIXON, ILLINOIS

Reynolds
Industrial
WIRE
CLOTH

For a Real "Beauty Treatment" *both* in Manufacturing and in Merchandising

. . . top equipment-makers use AMERICAN PHILLIPS SCREWS

BEAUTIFY COSTS! Assembly costs never look so good as when they're *slimmed down to 50% of what they used to be*... simply by equipping all assembly departments with skid-proof, slash-proof American Phillips Screws. That's why leading makers of beauty-shop equipment use this modern fastening that saves half the time and the spoilage imposed by slotted screws.

BEAUTIFY SALES! The modern mark of the American Phillips crossed recess is a buy-sign that the public has learned to accept with confidence on everything from autos to model railroads . . . and that industry has long since accepted (in fact, *specified*) on everything from trucks to machine tools. That mark means that the product is built right, all the way through. Yes, American Phillips Screws are potent sales-promoters as well as cost-cutters. Get both these advantages *for your own product.* Write and tell us to prove that "American Phillips Screws always cost least to use."

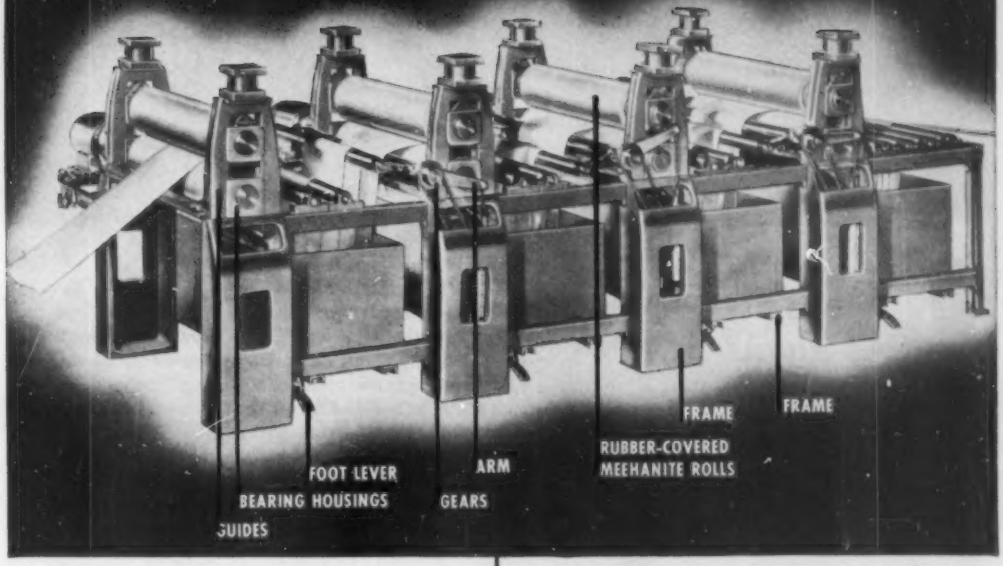
4-WINGED DRIVER CAN'T SLIP OUT OF PHILLIPS TAPERED RECESS

AMERICAN SCREW COMPANY, Providence 1, R. I.
Plants at Willimantic, Conn., and Norristown, Pa.
Warehouses at: 589 E. Illinois St., Chicago 11 — 502 Stephenson Building, Detroit 2

AMERICAN PHILLIPS *Screws*

ALL TYPES
ALL METALS: Steel, Brass, Bronze, Stainless Steel, Aluminum, Monel, Everdur (silicon bronze)

MEEHANITE® Properties make this Machine BETTER, STURDIER, FASTER



H. W. BUTTERWORTH & SONS CO., Philadelphia, are leading builders of a large line of textile industry equipment. Castings for their machinery are produced in their own Meehanite foundry. Their designers and engineers build in quality by utilizing from the beginning the better engineering characteristics available in the various types of Meehanite castings produced.

The photograph shows a Butterworth Compartment Washer and also indicates the variety of Meehanite castings used in every compartment.

To the equipment they provide higher vibration absorption properties; better strength characteristics; freedom from fear of hidden defects which might result in failure; in all,—a combination of those characteristics so important to builders of all types of equipment.

Write for Bulletin No. 32 entitled "Meehanite Quality Control Assures Uniform Dependability" to any of the foundries listed.

MEEHANITE FOUNDRIES

American Brake Shoe Co. — Mahwah, New Jersey
The American Laundry Machinery Co. — Rochester, New York
Atlas Foundry Co. — Detroit, Michigan
Banner Iron Works — St. Louis, Missouri
Barnett Foundry & Machine Co. — Irvington, New Jersey
H. W. Butterworth & Sons Co. — Bethayres, Pennsylvania
Continental Gin Co. — Birmingham, Alabama
The Cooper-Bessemer Corp. — Mt. Vernon, Ohio and Grove City, Pa.
Crawford & Doherty Foundry Co. — Portland, Oregon
Farrel-Birmingham Co., Inc. — Ansonia, Connecticut
Florence Pipe Foundry & Machine Co. — Florence, New Jersey
Fulton Foundry & Machine Co., Inc. — Cleveland, Ohio
General Foundry & Manufacturing Co. — Flint, Michigan
Greenlee Foundry Co. — Chicago, Illinois
The Hamilton Foundry & Machine Co. — Hamilton, Ohio
Johnstown Foundries, Inc. — Grove City, Pennsylvania
Kanawha Manufacturing Co. — Charleston, West Virginia
Kearney Co. — Milwaukee, Wisconsin
Lincoln Foundry Corp. — Los Angeles, California
E. Long Ltd. — Orillia, Ontario
Otis Elevator Co., Ltd. — Hamilton, Ontario
The Henry Perkins Co. — Bridgewater, Massachusetts
Pelton Foundry Co., Inc. — Buffalo, New York
Rosedale Foundry & Machine Co. — Pittsburgh, Pennsylvania
Ross-Meehan Foundries — Chattanooga, Tennessee
Shenango-Penn Mold Co. — Dover, Ohio
Smith Industries, Inc. — Indianapolis, Ind.
Standard Foundry Co. — Worcester, Massachusetts
The Stearns-Roger Manufacturing Co. — Denver, Colorado
Traylor Engineering & Mfg. Co. — Allentown, Pennsylvania
Valley Iron Works, Inc. — St. Paul, Minnesota
Vulcan Foundry Co. — Oakland, California
Warren Foundry & Pipe Corporation — Phillipsburg, New Jersey

"This advertisement sponsored by foundries listed above."

MEEHANITE

PERSHING SQUARE BUILDING • NEW ROCHELLE, N. Y.

WHEN TO USE SINGLE-ROW RADIAL-THRUST BEARINGS

If your application requires maximum capacity for thrust loads in *one direction only* or *combined radial and thrust loads* with predominant thrust load, specify Federal Ball Bearing Series 7200, 7300 or 7400.

These Federal bearings are so engineered that the angle of contact between the balls and the races will be more nearly in line with the resultant pressure from combined thrust and radial loads than would be the case with single row radial ball bearings. Higher outer ring shoulders on the thrust side and deep, continuous inner ring raceways assure maximum ball contact area. The low outer ring shoulder opposite the thrust face permits the use of the maximum number and size of balls. These features give Federals their consistently high load carrying capacity. The bearings are non-separable after assembly and not adaptable for pure radial loads.

Federal Single-Row Radial-Thrust Bearings are made in light, medium and heavy series to cover a wide range of applications. Our Catalog "K" includes ball bearing selection charts to help you compute bearing loads, determine load ratings for all bearings at all speeds, and select the type and size ball bearing best suited to your application. It also describes these and one of the most complete lines of ball bearings...every type and size...shielded and sealed...for every anti-friction need. (A few of the many types are illustrated above.) Write for your copy today.

THE FEDERAL BEARINGS CO., INC. • POUGHKEEPSIE, NEW YORK

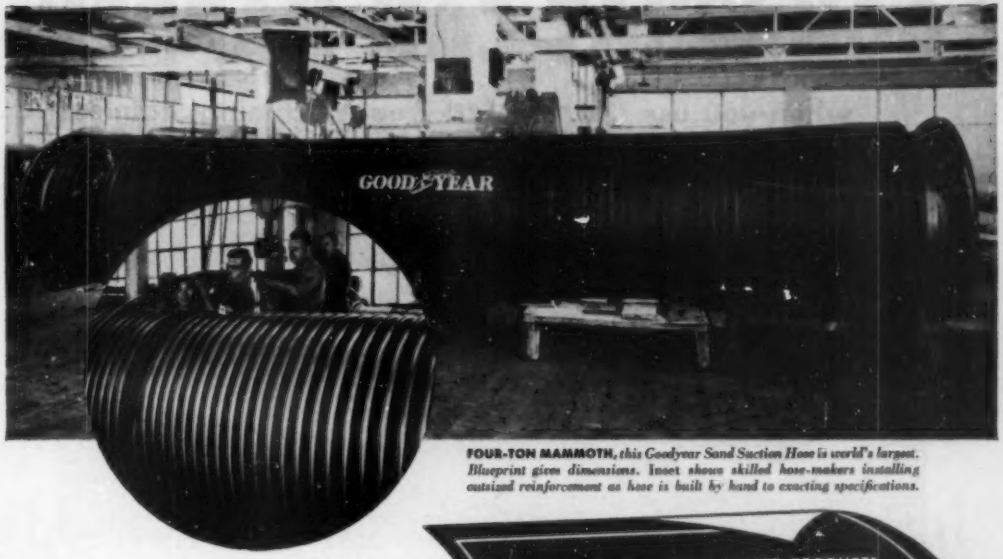
Makers of Fine Ball Bearings

REPRESENTATIVES LOCATED AT

2649 Book Tower, Detroit 26, Michigan • 6 South Michigan Ave., Chicago 3, Illinois
Chester-Twelfth Building, Cleveland 14, Ohio

FEDERAL BALL BEARINGS

ONE OF AMERICA'S LEADING BALL BEARING MANUFACTURERS



FOUR-TON MAMMOTH, *this Goodyear Sand Suction Hose is world's largest. Blueprint gives dimensions. Inset shows skilled hose-makers installing outsized reinforcement as hose is built by hand to exacting specifications.*

How big a hose do you need

–from ⅛-inch to 38-inch?

GOODYEAR INDUSTRIAL RUBBER PRODUCTS

GIR-Specified

SAND SUCTION HOSE

Reinforced with coil of ⅜" copperized steel wire and 15 plies of rubberized fabric

47" O.D. (over nipples) 38" I.D.

20' L.O.A.

weight 8,680 lbs. per length

FOR HOSE, FLAT BELTS, V-BELTS, MOLDED GOODS, PACKING, TANK LINING built to the world's highest standard of quality, phone your nearest Goodyear Industrial Rubber Products Distributor.

WORLD'S largest sand suction hose — a 38-inch I.D. giant, 20 feet long, weighing 8,680 pounds — has just been built by Goodyear for a huge Mississippi River dredge.

The same technical skill and knowledge that helped the G.T.M. — Goodyear Technical Man — design this mammoth hose have also produced hose as small as ⅛-inch — the low-expansion, high-burst brake hose used on all passenger cars. This same skill and knowledge are at your service for the selection of any hose *you* need — from specially-built types to one of the more than 800 standard hoses built by Goodyear to meet specific service conditions. To reach the G.T.M., phone your nearest Goodyear Industrial Rubber Products Distributor, or write Goodyear, Akron 16, Ohio.

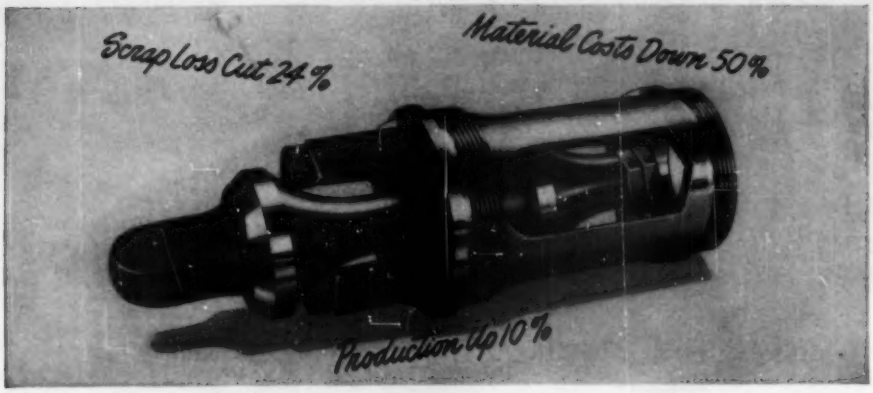
We think you'll like "THE GREATEST STORY EVER TOLD"—Every Sunday—ABC Network

GOODYEAR

THE GREATEST NAME IN RUBBER

LOOK WHAT CAN HAPPEN

when you use *Carpenter* Free-Machining Stainless . . .



3" streamflow-type plunger and cage for valve used to control flow of fluids under pressure. Machining tolerances on the job are close and good finishes an absolute "must".

A combination of corrosion resistance, wear resistance and strength to withstand high pressures is the first requirement on this precision-machined part.

That's why it was first made from a Stainless casting. But when the job was discussed with Carpenter's representative, here is what happened . . .

- With the change from castings to Carpenter Stainless No. 5 (Type 416) the required physicals were provided *at a 50% saving in cost for material.*
- Carpenter Stainless No. 5 is easy to machine, and as a result of its use on this job *scrap loss was cut by 24%.*
- Unit production with No. 5, heat treated to 300 Brinell, increased by 10% per shift.

You Can Get Results Like This On Your Own Jobs . . .

. . . and the best way to do it is to place your next production order for Carpenter Stainless No. 5 (Type 416) or No. 8 (Type 303) and *make your own comparison.* Call your Carpenter Warehouse for fast delivery. See your classified telephone directory.

Another advantage in using Carpenter Stainless is the kind of help you can get on machining jobs. And that means know-how based on long experience, when you remember that Free-Machining Stainless was invented by Carpenter.

The 96-page Carpenter "NOTEBOOK on Machining Stainless Steels" is helping many Stainless users get lower unit costs on their jobs. For this useful guide on Turning, Threading, Drilling, etc. send us a note on your company letterhead. Extra copies of the NOTEBOOK, for your men, are available at 50¢ apiece.

THE CARPENTER STEEL COMPANY
117 W. Bern Street • Reading, Pa.

Export Department: 233 Broadway, New York 7, N.Y. "CARSTEELCO"

Carpenter
FREE-MACHINING
STAINLESS STEELS

WHEN YOU HAVE A STAINLESS PROBLEM—YOU CAN COUNT ON CARPENTER FOR THE ANSWER

Greater ease in use accompanies products made lighter with Dow

MAGNESIUM

the world's lightest structural metal!

If you are looking for a way to improve your product, one metal, Magnesium, deserves your first consideration.

Magnesium is the world's lightest structural metal—a full one-third lighter than its closest rival. Put this extra lightness to work improving your products. Materials handling equipment, business machines, portable tools, truck bodies, and reciprocating machinery are but a few of the fields where magnesium lightness has been used to great advantage.

Maximum lightness isn't all magnesium has to offer. It's the easiest of all metals to machine and is readily adapted to all standard fabricating techniques. Available in all common forms, magnesium is surprisingly low in cost.

See how leading designers in many fields have used magnesium to improve their products. Send for your free copy of "How Magnesium Pays."

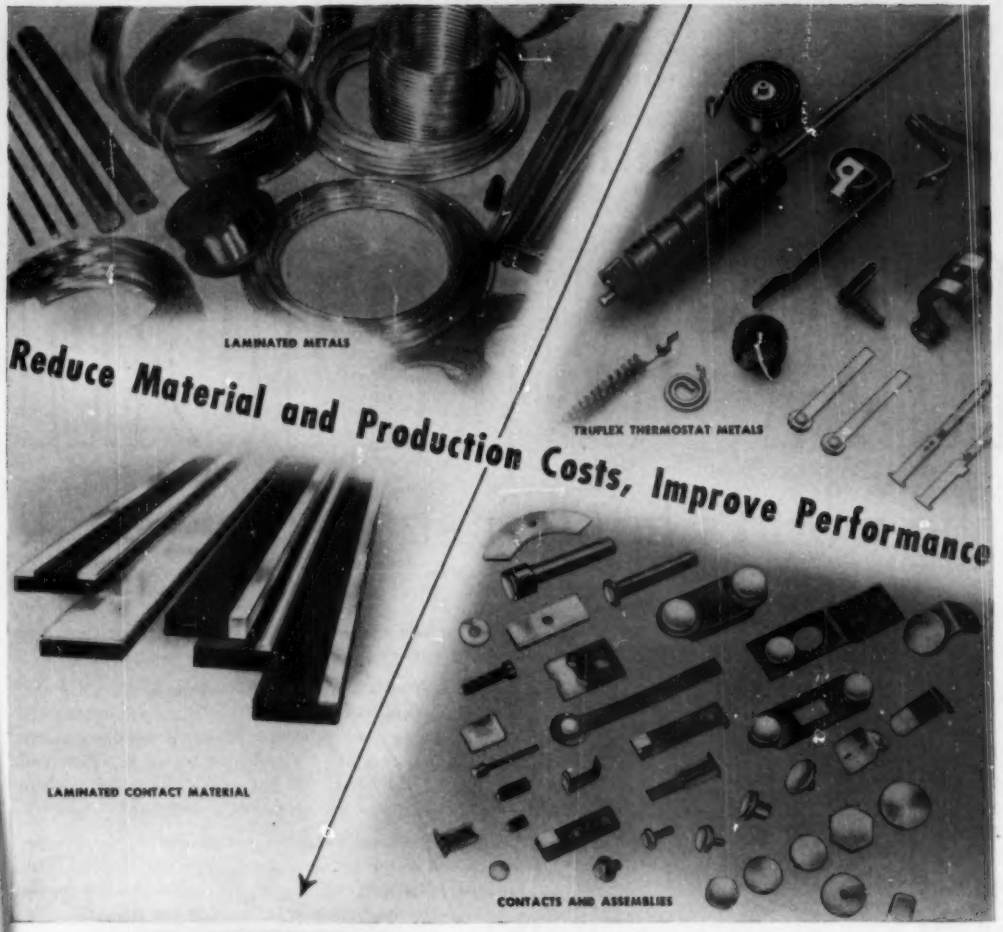
THE DOW CHEMICAL COMPANY, MIDLAND, MICHIGAN

New York • Boston • Philadelphia • Washington • Atlanta • Cleveland • Detroit
Chicago • St. Louis • Houston • San Francisco • Los Angeles • Seattle
Dow Chemical of Canada, Limited, Toronto, Canada

Simplify Product Design— Speed Production and Assembly . . . with Magnesium

Leading manufacturers are using magnesium wherever they can. They've found that magnesium is as versatile and workable as it is light. Magnesium extrusions streamline design and production because they are available in an almost unlimited variety of shapes. Magnesium sand castings provide good strength, shock resistance and ease of machining. Magnesium sheet is strong without being heavy and is readily fabricated by well-known methods.

Lighter Products Sell—make your product Magnesium Light!



with

GENERAL PLATE

Precious and Composite Metals and Products

The versatility of General Plate Laminated Metals, Truflex Thermostat Metals, Contact materials and finished assemblies enables you to simplify designs, reduce the amount of high cost metals . . . maintain precious metal performance.

Through long years of experience in the manufacture of precious to base metal and base to base metal combinations . . . and work with leading manufacturers of electrical and industrial products, General Plate gives you laminated raw materials and finished assemblies that provide economical solutions to your problems.

In precious to base metal combinations, General Plate saves you dollars by eliminating a large waste of the precious metal. Base metal laminates provide physical properties not found in single metals.

Write for complete information about General Plate Products today. Our engineers will help you with your problems.

GENERAL PLATE PRODUCTS INCLUDE:

- Truflex Thermostat Metals.
- Precious to base metal laminations.
- Base metal laminations.
- Alcuplate (copper on aluminum).
- Silver solders.
- Laminated contacts, buttons, rivets.
- Platinum — fabrication — refining.
- Age-hardening Alloy 720.

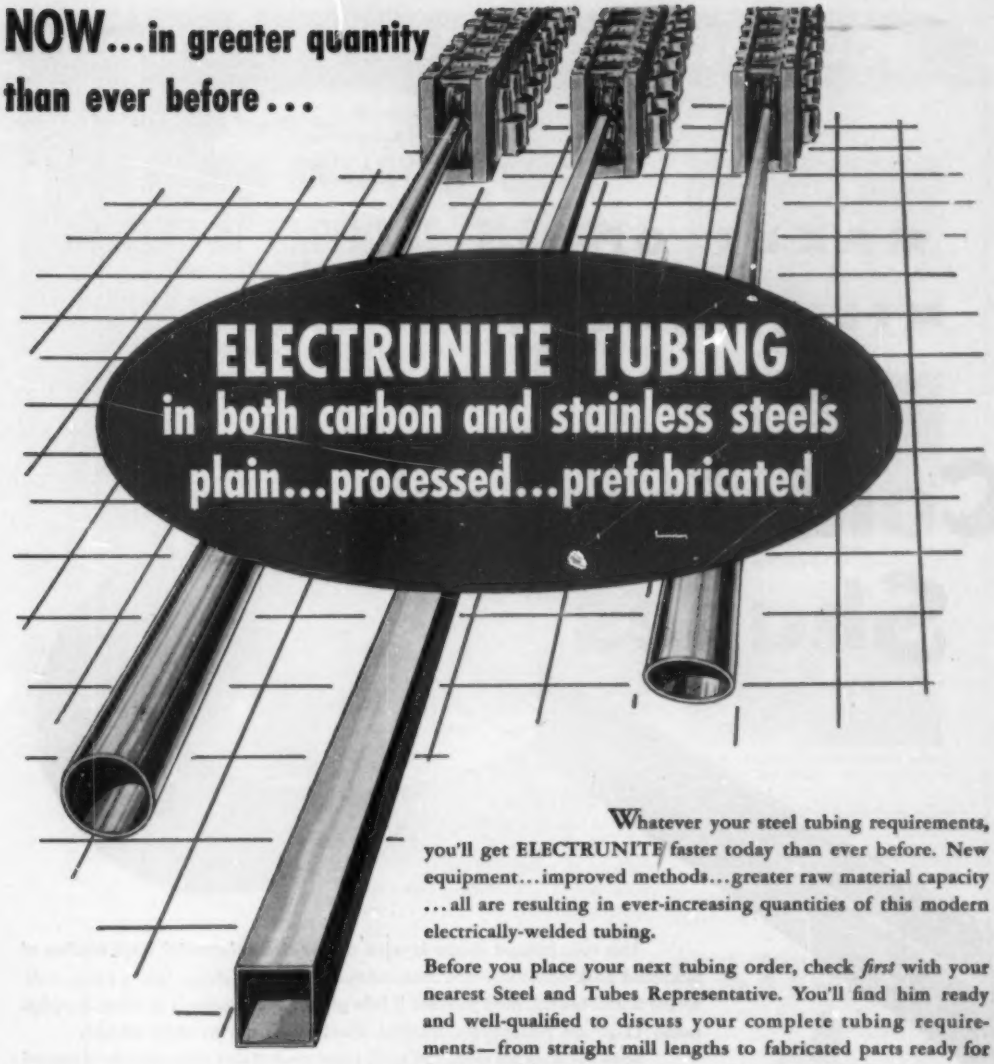
I-220

GENERAL PLATE

Division of Metals & Controls Corporation

102 FOREST STREET, ATTLEBORO, MASSACHUSETTS

NOW...in greater quantity than ever before...



Whatever your steel tubing requirements, you'll get ELECTRUNITE faster today than ever before. New equipment...improved methods...greater raw material capacity ...all are resulting in ever-increasing quantities of this modern electrically-welded tubing.

Before you place your next tubing order, check *first* with your nearest Steel and Tubes Representative. You'll find him ready and well-qualified to discuss your complete tubing requirements—from straight mill lengths to fabricated parts ready for final assembly.

Write, wire or phone *today*.

REPUBLIC STEEL CORPORATION
STEEL AND TUBES DIVISION • CLEVELAND 8, OHIO
Export Department: Chrysler Building, New York 17, New York

Republic
REPUBLIC STEEL
ELECTRUNITE TUBING

MAKER OF MILK CANS USES

Cold-Formed Shapes

This cold-formed shape is used as the circumferential base section of standard milk cans. The can manufacturer rolls the shape into a hoop, butt-welds it end-to-end, then presses it into place. We supply it in 83-in. lengths, using 11-gauge commercial-quality sheet steel, cut in strip widths.

Base sections for standard milk cans are but one of hundreds of varied uses for Bethlehem Cold-Formed Shapes. The versatility of these shapes and the savings they make possible have led to their adoption in an ever-widening range of products. New uses keep turning up almost every day.

Bethlehem Cold-Formed Shapes are made from strip, sheets, or plates. They are uniform in thickness, practically free from scale, and have an excellent strength-weight ratio. They come in all gauges from 7 to 24, inclusive.

Although you may not have suspected it, there's very likely a money-saving use for Bethlehem Cold-Formed Shapes in your own plant. Get in touch with us, and we'll arrange for a Bethlehem representative to analyze your operations and offer suggestions. No obligation, of course.

BETHLEHEM STEEL

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

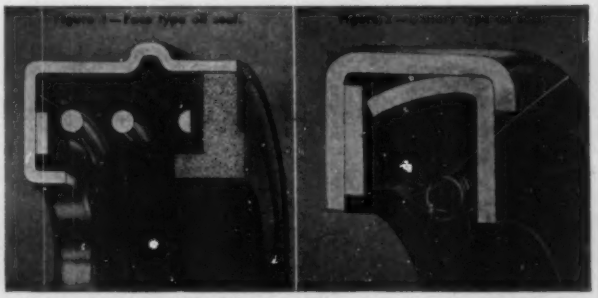
On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation

Export Distributor: Bethlehem Steel Export Corporation

NATIONAL OIL SEAL LOGBOOK

USE OF NEW UNITARY OIL SEALS INSTEAD OF EXPENSIVE FACE TYPES

Many tough applications where face type seals have been thought necessary are now utilizing unitary oil seals at substantial savings in cost. Farm implements, tractors, track tread units and other machinery which operate in heavy dirt under adverse conditions are typical of these applications.



Note mechanical complexity of face type seal as compared to unitary type oil seal.

The advent of new sealing member of synthetic compounds and development of new treatments for leather, coupled with a considerable advance in mechanical design of the oil seal itself, have made practical their use in some of the most rugged and exacting applications. Savings are effected in the cost of the sealing unit and in the cost of manufacturing of the equipment itself. In addition, servicing of the equipment is greatly simplified.

The sectional drawings (Figs. 1 & 2) show the complexity of the face type seal as compared to the unitary type, which accounts for the low cost of the one versus the other. It is apparent that a unitary type seal can be more easily incorporated mechanically with resultant savings in the manufacture of the equipment.

Many new unitary oil seal designs have been developed which solve difficult problems. A few of these are shown (Figs. 3, 4 & 5). The dual wipe seal shown (Fig. 3), having Syntech* sealing members, was designed for a farm implement application which formerly utilized an expensive face type seal. This particular seal provides vastly improved performance in this type of equipment.

National Oil Seal engineers recommend face type oil seals only when thorough research proves them absolutely necessary and practical.

No matter what your problems—whether requiring face types, special sealing member compounds or adaptations of stock designs—National Oil Seal engineers will gladly help you. A quarter century of experience is your assurance of dependable assistance.

Figure 3—National Series 330,000 Syntech* dual wipe oil seal.

Figure 4—National convoluted flex type oil seal permits extreme shaft misalignment.

Figure 5—National Series 350,000 rubber-covered oil seal requires less critical bore.

NATIONAL OIL AND FLUID SEALS

NATIONAL MOTOR BEARING CO., INC.

General Offices: Redwood City, Calif.
Plants: Redwood City and Los Angeles, Calif.; Van Wert, Ohio

*Trade Mark Registered

3048

CALL IN A NATIONAL ENGINEER FOR RECOMMENDATIONS

BUFFALO: 56 Arlington Place, Grant 2280.
CHICAGO: Room 2014 Field Building, Central 6-8663.
CLEVELAND: 210 Heights Rockefeller Bldg., Yellowstone 2720.
DALLAS: 30½ Highland Park Village, Justin 8-8453.
DETROIT: Room 1026 Fisher Building, Trinity 1-4363.
HOUSTON: 6731 Harrisburg Boulevard, Wayside 3-1246.
LOS ANGELES: 2244 East 37th Street, Kimball 6384.
MILWAUKEE: 647 West Virginia St., Marquette 8-8986.
NEW YORK CITY: 122 East 42nd Street, Lexington 2-8260.
PHILADELPHIA: 401 North Broad Street, Bell-Walnut 2-6997.
REDWOOD CITY, CALIF.: Broadway and National, Emerson 6-3861.
WEST SPRINGFIELD, MASS.: 1025 Elm Street, Springfield 2-1001.
EAST SYRACUSE, N. Y.: 226 Roby Avenue, East Syracuse 366.
WICHITA: 340 North St. Francis Ave., Wichita 2-6971.

The *knurling* on the head of the UNBRAKO Socket Head Cap Screw saves valuable assembly time because the UNBRAKO can be screwed in faster and further with the fingers—the handiest of all wrenches—before a wrench is needed. The slip-proof knurling "gears" the screw to the fingers, even when they are oily or greasy . . . this is especially important in the smaller sizes.

So, use Knurled UNBRAKO Socket Head Cap Screws and *save time and money.*

Write for further information.

Knurled Head Socket Cap Screws
Flat Head Socket Cap Screws
Self-Locking Socket Set Screws

SOCKET **UNBRAKO** SCREWS

Knurled Head Stripper Bolts
Precision-Ground Dowel Pins
Fully-Formed Pressure Plugs

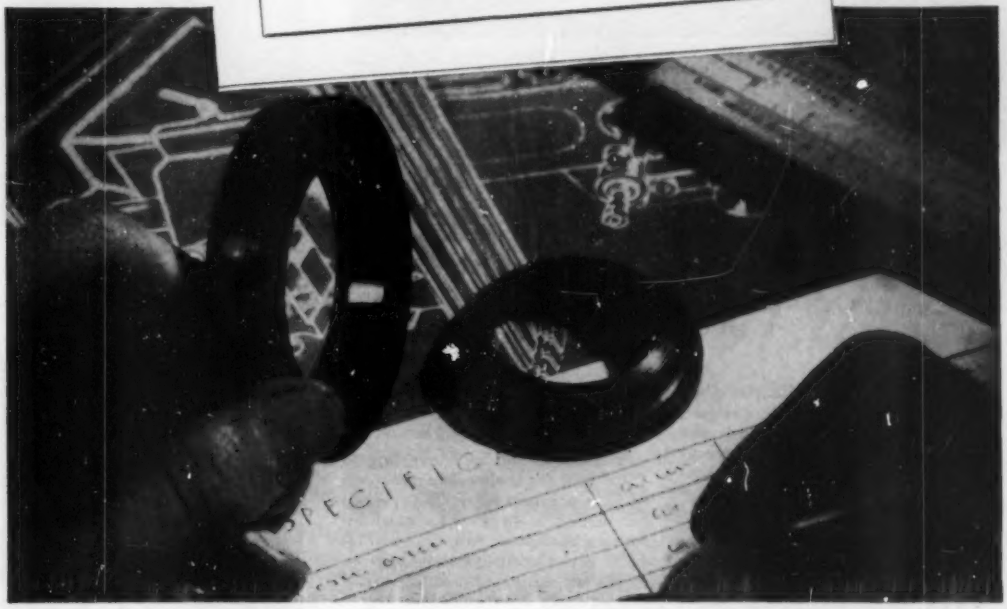
SPS STANDARD PRESSED STEEL CO.

JENKINTOWN 28, PENNSYLVANIA

YOUR NAME GOES HERE . . .

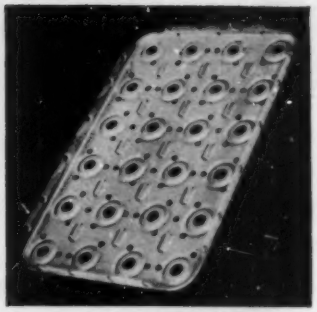
.....

is cordially invited to
make full use of
Houghton's Packing Engineering
Service when you need
help in designing
packing installations

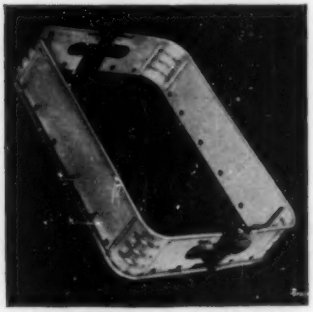


Yes, sir, if hydraulic design is your responsibility, and you desire advice on a packing installation, this is your invitation. Houghton hydraulic engineers have been doing that sort of first-aid for many years, which is one big reason why our packings are so well and favorably known. For proper recommendation of the right style of leather or synthetic rubber packings, contact E. F. Houghton & Co., Philadelphia 33, and all principal cities.

HOUGHTON'S VIM LEATHER AND VIX-SYN
Engineered Packings



These are the parts of the patented bottle case—produced by modern assembly-line methods: Into a punch press goes a coil of 150S—out comes finished case bottoms.



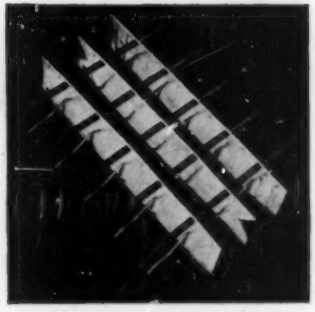
Two spools of coated steel wire and a coil of 150S are simultaneously fed into a rolling machine to form the body in a completely automatic operation.

One every 6 seconds from 150S

Metal Carrier Corporation, Grand Rapids, produces long-lasting, rust-proof aluminum bottle cases like this at the rate of one every six seconds!

By using the new Kaiser Aluminum alloy 150S in place of 52S, they save production steps, slash production costs 4¢ per unit. And they turn out an easily formed case that's strong and durable, that never needs paint, that weighs only 3½ pounds.

You can profit by converting to 150S, too! *It's the world's most versatile aluminum alloy.* Today—call our nearest sales office for more information. Kaiser Aluminum alloy 150S is the exclusive development of Kaiser Aluminum & Chemical Corporation.



Interior bottle divider is formed on a third line of rolling machines and punch presses. Parts are automatically conveyed into the final assembly line, where the interior nest is snapped into the body.

Kaiser Aluminum

SOLD BY KAISER ALUMINUM & CHEMICAL SALES, INC., KAISER BUILDING, OAKLAND 12, CALIF. . . . OFFICES IN:
Atlanta • Boston • Chicago • Cincinnati • Cleveland • Dallas • Denver • Detroit • Houston • Indianapolis • Kansas City • Los Angeles
Milwaukee • Minneapolis • New York • Oakland • Philadelphia • Portland, Ore. • Rochester, N. Y. • Seattle • Spokane • St. Louis
Wichita • EXPORT OFFICE, OAKLAND, CALIFORNIA • WAREHOUSE DISTRIBUTORS IN PRINCIPAL CITIES

C/R *dependability costs you NOTHING*

Five thousand dollars for one oil seal! It isn't so startling to Chicago Rawhide engineers. Pilot oil seal models often cost that. And more. Research is costly. But C/R research saves money for you. It gives you the maximum of product dependability.

Since the days when Chicago Rawhide made the early automotive oil seals, C/R research has been applied to the solution of fluid retention and exclusion problems in every type of mechanism. This research has had just one aim: complete dependability under all circumstances. As a result, Chicago Rawhide has become the world's largest manufacturer of shaft-type oil seals. This C/R experience is important to you, because dependability can not be measured in ordinary specifications.

When you select C/R "Perfect" Oil Seals, you know they'll be right for the job. Each is specially engineered —correctly designed to assure dependable performance. C/R research helps you build a high degree of dependability in your own product. It costs you nothing.

Chicago Rawhide engineering service is always available for the solution of your particular sealing problems.

CHICAGO RAWHIDE MANUFACTURING CO.

1299 Elston Avenue **OIL SEAL DIVISION** Chicago 22, Illinois

Chicago Rawhide Manufacturing Company specializes in mechanical sealing and protective products: oil seals and special diaphragms, boots, gaskets, washers and packings of *Sirvene* synthetic rubber and *Sirvis* mechanical leather.

ENGINEERS: We will be pleased to send you engineering data on "Perfect" Oil Seals on receipt of your written request.

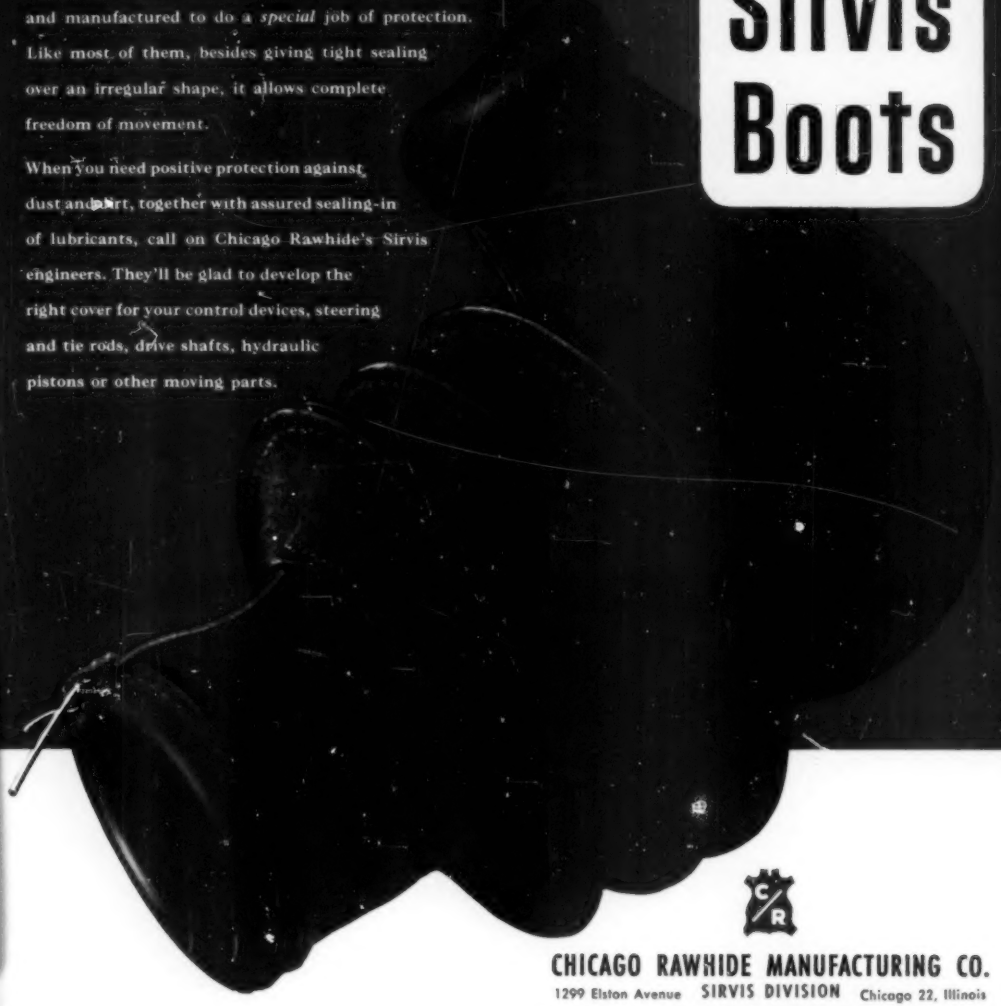
PERFECT
Oil Seals

FOR TIGHT SEALING OVER IRREGULAR SHAPES

This is a strange-looking boot. But it is typical of all Sirvis leather protective boots in that it was designed and manufactured to do a *special* job of protection. Like most of them, besides giving tight sealing over an irregular shape, it allows complete freedom of movement.

When you need positive protection against dust and dirt, together with assured sealing-in of lubricants, call on Chicago Rawhide's Sirvis engineers. They'll be glad to develop the right cover for your control devices, steering and tie rods, drive shafts, hydraulic pistons or other moving parts.

Sirvis Boots



CHICAGO RAWHIDE MANUFACTURING CO.

1299 Elston Avenue **SIRVIS DIVISION** Chicago 22, Illinois

Chicago Rawhide Manufacturing Company specializes in mechanical sealing and protective products: oil seals and special diaphragms, boots, gaskets, washers and packings of *Sirvene* synthetic rubber and *Sirvis* mechanical leather.

For detailed information about Sirvis products, write for the free Chicago Rawhide catalog.

SIRVIS

COPPER ALLOY BULLETIN

REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

Prepared Each Month by BRIDGEPORT BRASS COMPANY "Bridgeport" Headquarters for BRASS, BRONZE and COPPER

In a line in the center of the photograph is the body with base and cover in front. At the front left are the two half sections of the spout—Courtesy Manning-Bowman Co., Meriden, Conn.

Improved Quality, Reduced Costs Possible Through Brass

Product designers are striving hard to keep their goods ahead of the procession in the steadily growing buyers' market. Many old methods of manufacture are being discarded and materials are being selected with greater care to market goods of higher quality and, if possible, at a lower cost.

Use of stampings and screw machine parts to replace castings, especially where finishing and plating are necessary, is becoming more common. High foundry costs and the need to reduce expensive finishing operations and high scrap losses, is behind this trend.

The electric coffee percolator, manufactured by Manning, Bowman Co., Meriden, Conn., serves as an ideal example of the efforts of the product designer to meet active competition.

The percolator, excluding heating unit, glass top and handle, has four main parts—body, cover, spout and base which contains the heating unit.

Low brass, 80% copper and 20% zinc, is used for the body and bottom while commercial bronze strip metal, 90% copper and 10% zinc, is used for the cover and the two-piece spout.

Slush Casting Eliminated

For many years white metal slush castings were used for spouts. However, despite the low cost, there were many disadvantages in this type of spout: the nickel-chrome plate had a tendency to peel and the color tone was rarely a perfect match to the body.

Now, the spout is fabricated from two stampings of commercial bronze. This is more ductile than 80-20 yet work hardens enough so that after press forming, danger of denting is minimized. Silver solder joins the two sections together and to the body.

Mechanical Strength High

Since the base and body are subjected to danger of denting during normal use in the home, 80-20 brass was selected due to its naturally high tensile strength and hardness which are increased greatly through the cold working operations.

From the manufacturing side this brass is subjected to rough treatment in the bulging operation put on the body. Bulging is a stretching operation and the metal must have sufficient tensile strength to keep from tearing.

Buffing is also facilitated on this alloy because a fine grain structure is assured through care in annealing.

Bead and rolled grooves at the top of the body and the base increase the beauty of the product and stiffen the sections for greater strength.

Nickel Silver for White Color Base

An interesting use of an alloy for color as well as corrosion resistance is found in the piece which receives the valve in the base of the percolator.

Nickel silver, 65% copper and 18% nickel, is used for this part. Due to continual insertions and removing of the coffee tube, wear is quite high. Although this part is nickel-chrome plated, the plate wears off in time. With nickel silver the white color remains despite wear, keeping the inside of the percolator shiny and clean.

In a product such as this, copper-base alloys give the ultimate in beauty, ability to withstand abuse and wear, as well as corrosion. Added to this is the ease with which these alloys can be worked, buffed and plated.

Metal problems involving reduction in manufacturing costs through change in alloys and temper will gladly be handled by our Metallurgical Laboratory — Contact our nearest District Office for Bridgeport service.

BRASS · BRONZE · COPPER · DURONZE — STRIP · ROD · WIRE · TUBING

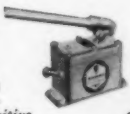
MILLS IN
BRIDGEPORT, CONNECTICUT
INDIANAPOLIS, INDIANA
In Canada:
Noranda Copper and Brass Limited, Montreal

BRIDGEPORT BRASS COMPANY
BRIDGEPORT 2, CONNECTICUT
Established 1865
"Bridgeport" *District Offices and Warehouses in Principal Cities*

"I Bank on for Hydraulic Controls

"PUMPS... man alive, you should see how Blackhawk units pour horsepower into the job! Cold or hot weather is no bugaboo . . . and the low-price will astound you!"

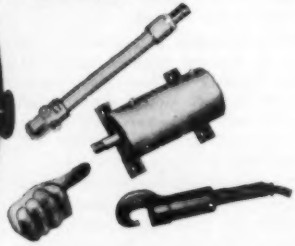
Yes, practically all the available horsepower goes *to work* when a Blackhawk *POWER-DRIVEN PUMP* is in action! In fact, with some units, volumetric efficiencies run over 90% at high pressures. The Blackhawk piston-type design gives you *positive* displacement — whether you need 1000, 2000, 3000, 4000 . . . *yes,* even up to 10,000 p.s.i.



No other pump in this field enjoys the sales record of "POWER-PACKER"! This famous Blackhawk *HAND-OPERATED* pump wins its way because of big exclusives, a service-proved reputation and attractive price. And now, you can get a "*Junior* Power-Packer"—at an even lower cost!

ASK FOR PUMP BULLETINS NOS. 1P, 2P, 3P AND 4P.

"RAMS have come to me from Blackhawk for 25 years — without field headaches! The leakproof designs are so simple and compact . . ."



What'll you have? Choose from *STANDARD, CATALOGED RAMS* — or order SPECIALS to answer the most unique purposes. You can get them in either single-acting or double-acting designs and in any length.

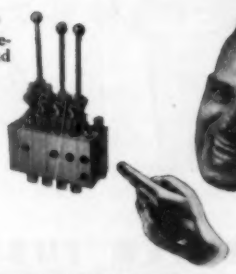
ASK FOR RAM BULLETIN NO. 1R.

Scores of critical designers and buyers recognize that Blackhawk Hydraulics create exclusive advantages for the engineering, manufacturing and sale of their products. Many use *complete* Blackhawk systems, thus gaining extra and *unique* benefits from high-pressures — a field in which Blackhawk is a pronounced leader.

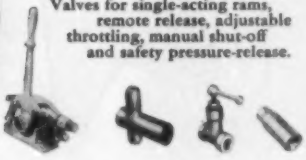
Blackhawk and Here's Why..."

"VALVES from Blackhawk spell precision control down to a molecule's whisker. They're positive-acting . . . and I can get single units or combinations to answer any and all of my needs . . ."

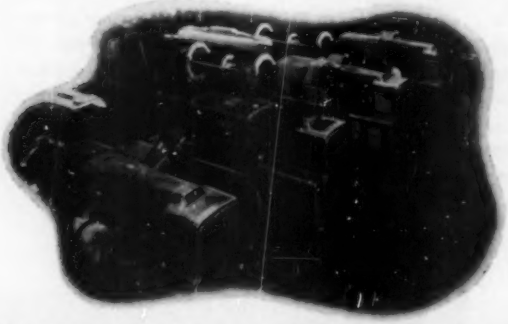
You'll find the new *"VALVBANK"* control system the last word for precision throttling on both raising and lowering. Standardized sections build into unlimited combinations—to serve either single-acting or double-acting rams, fluid motors or other hydraulic equipment.



You can also get Blackhawk Valves for single-acting rams, remote release, adjustable throttling, manual shut-off and safety pressure-release.



ASK FOR VALVE BULLETINS NOS. 1V, 2V AND 3V.



Expanded, Unmatched Facilities are here for building hydraulic equipment. Because of continuous production and widespread use, standard, cataloged components *are available from stock at attractive prices.* We also have the engineering and manufacturing facilities to develop and produce hydraulic equipment of special designs. We especially invite your requests for quotation on specialized *ram* requirements.

We invite you to write for free technical bulletins listed above—or, if you prefer, request them in the complete MASTER BINDER NO. OE which also contains helpful pictorial data on applications. Engineering Counsel is willingly furnished—in confidence. Blackhawk—the world's largest manufacturer of High-Pressure Hydraulic Equipment—welcomes inspection of its plant. **BLACKHAWK MFG. CO., 5302 W. Rogers St., Milwaukee 1, Wis.**

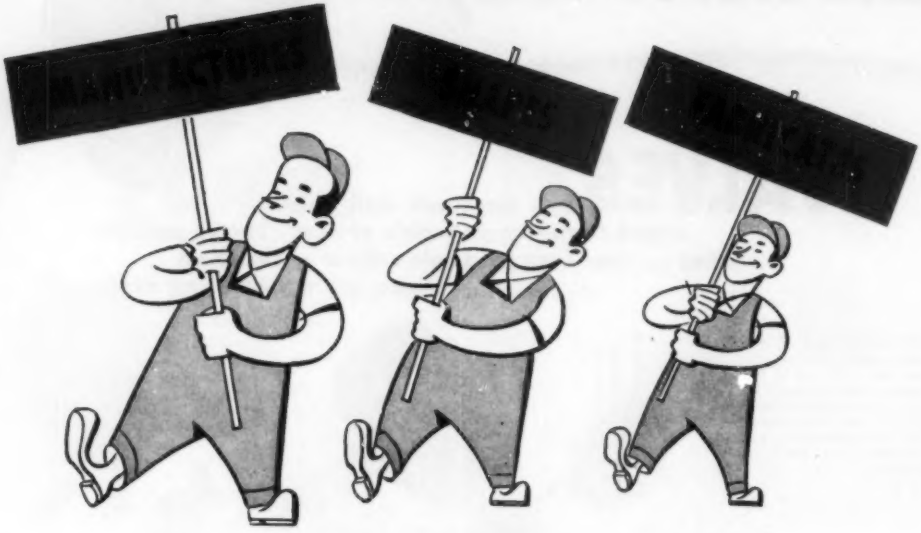
BLACKHAWK HYDRAULIC EQUIPPED

An Emblem Representing Dependability Throughout Industry

BLACKHAWK

5302 W. Rogers St., Milwaukee 1, Wis.

Ostuco does all three...



ELECTRIC WELDED TUBING

Now you can cut production costs, improve product quality, and get faster deliveries, by using OSTUCO Electric Resistance Welded Steel Tubing, because OSTUCO has expanded facilities for doing *all three* tubing operations — manufacturing, shaping, and fabricating.

OSTUCO procures the raw materials . . . produces Carbon Mechanical Grades of electric welded steel tubing in a broad range of sizes and shapes . . . quickly meets your most exacting requirements in all types of fabricating operations. We are also in a position to supply the tubes painted or plated.

OSTUCO's single source operation eliminates unnecessary freight charges. Unified control of production assures highest quality. Speedy shipments enable you to operate with lower inventories. Prompt engineering assistance and job quotations without obligation. Write direct or to our nearest Sales Office for new free booklet "OSTUCO Electric Resistance Welded Steel Tubing."

OSTUCO

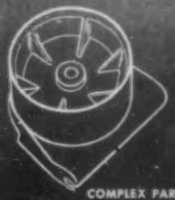
THE OHIO SEAMLESS TUBE COMPANY

Manufacturers and Fabricators of Seamless and Electric-Welded Steel Tubing

Plant and General Offices: SHELBY 7, OHIO

Sales Offices: CHICAGO, Civic Opera Bldg., 20 North Wacker Dr. CLEVELAND, 1328 Citizens Bldg. • DAYTON, 511 Salem Ave. • DETROIT, 2857 E. Grand Blvd. • HOUSTON, 6833 Avenue W. Central Park • LOS ANGELES, Suite 300-170 So. Beverly Drive, Beverly Hills MOLINE, 617 15th St. • NEW YORK, 70 East 45th St. • PHILADELPHIA, 1413 Packard Bldg., 15th & Chestnut • ST. LOUIS, 1230 North Main St. • SEATTLE, 3104 Smith Tower • SYRACUSE, 501 Roberts Ave. CANADIAN REPRESENTATIVE, Railway & Power Corp., Ltd., NEW GLASGOW, MONTREAL, NORANDA, NORTH BAY, TORONTO, HAMILTON, WINDSOR, WINNIPEG, EDMONTON, VANCOUVER

HIGH PRODUCTION
AT LOW COST
ALCOA CASTING



COMPLEX PART AT LOW COST
ALCOA DIE CASTING

HOUSING
LIGHT WEIGHT
LASTING BEAUTY
ALCOA SHEET

DESIGN FOR SALES *with the help of this SINGLE SOURCE*

Today's design engineer aims for the traditional objectives of strength, performance and simplified production. But also, he seeks to break with tradition, to design for *sales*.

That is why he is looking more and more at the light weight, corrosion resistance, and low cost of Alcoa Aluminum. Discovering the further, specific advantages of semi-fabricated Alcoa products, made in Alcoa plants, to Alcoa quality standards, and available through a single, dependable source.

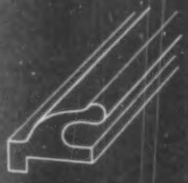
Alcoa gives him unbiased recommendations on the form of Alcoa Aluminum most convenient for each application, the alloy and temper for best service, and sound general advice on designing and fabricating aluminum, based on 62 years of aluminum experience.

If you are sales-designing for 1950 competition, Alcoa assistance is as near as your telephone.

CORROSION RESISTANCE
ALCOA TUBING

STRENGTH—SMOOTHNESS
ALCOA FORGING

CYLINDRICAL SHAPE
ONE END INTEGRAL
ALCOA IMPACT EXTRUSION



INTRICATE SHAPE
ALCOA EXTRUSION

SECURE ASSEMBLY
ALCOA FASTENERS

IN THE FOLLOWING PAGES, ALCOA PRESENTS FACTS FOR SALES DESIGNERS ON REPRESENTATIVE ALCOA PRODUCTS. ON THE LAST PAGE OF THE ALCOA SECTION WILL BE FOUND THE ALCOA OFFICES THROUGH WHICH INFORMATION ON ALUMINUM IS AVAILABLE. Aluminum Company of America, Gulf Bldg., Pittsburgh 19, Pa.

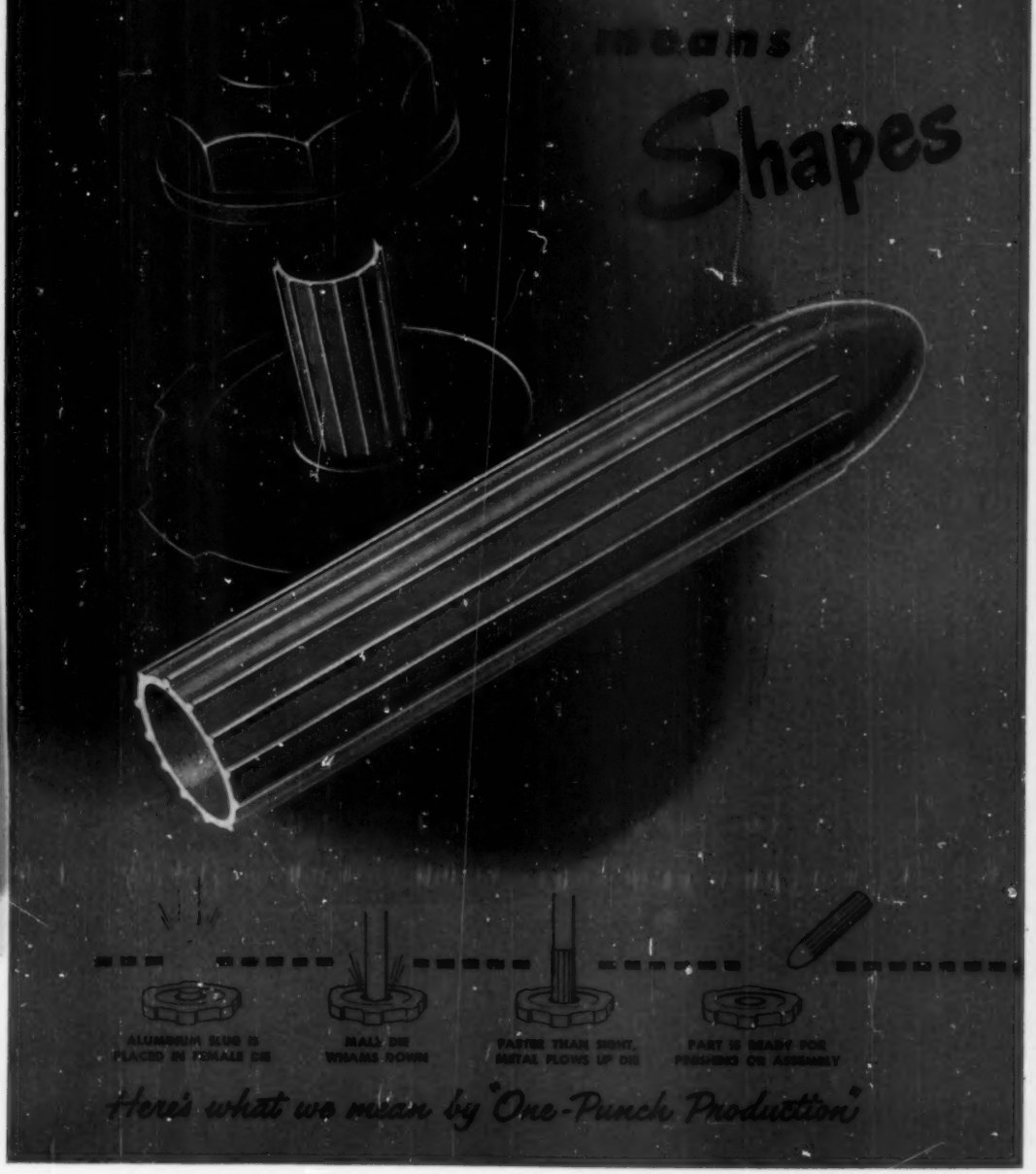
ALCOA FIRST IN ALUMINUM

THE ALCOA PRODUCTS ADVERTISED HERE ARE BACKED BY THE BASIC ENGINEERING LITERATURE OF THE INDUSTRY...

ONE-PUNCH PRODUCTION

means

Shapes


ALUMINUM SLUG IS PLACED IN FEMALE DIE
MALE DIE WHAMS DOWN
FASTER THAN SIGHT, METAL FLOWS UP DIE
PART IS READY FOR FINISHING OR ASSEMBLY

Here's what we mean by "One-Punch Production"

IN ADAPTING THEM TO YOUR USE, YOU ARE INVITED TO MAKE FULL USE OF ALCOA'S OUTSTANDING ENGINEERING HELP

like this can cost less as ALCOA IMPACT EXTRUSIONS

Can you visualize your product—or any part—as a hollow symmetrical shape? If the answer is yes—or maybe—Alcoa Impact Extrusions offer a way to get it made faster and cheaper. Cheaper than stamping, spinning, drawing, turning. And with sales-winning attractiveness.

Alcoa's split-second production process turns out complex or simple shapes in one all-productive "smack". Quicker than your eye can follow. Complete with ribs or flutes or bosses or other embellishments that would consume more time and require more costly dies by any other process.

If you see possibilities in this process for your product, call your Alcoa representative for more information about it, and for your free copy of "Alcoa Impact Extrusions."

Or write ALUMINUM COMPANY OF AMERICA, 2140B Gulf Building, Pittsburgh 19, Pennsylvania.

Imagineering with Alcoa Impact Extrusions lets you do any or all of these things:

LOWER YOUR COSTS—dies for Alcoa Impact Extrusions cost less than drawing dies. The difference is your savings.

CHOOSE ALMOST ANY HOLLOW SHAPE—virtually any symmetrical hollow shape can be impact extruded.

DESIGN FOR LENGTHS up to 12″ and diameters to 5″. Greater diameters and lengths possible varying according to design.

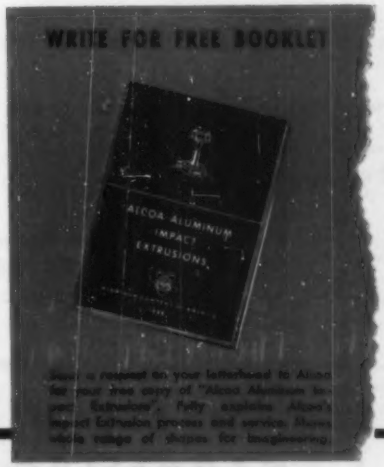
VARY THE WALL THICKNESS for decoration or function. Lugs, fillets, bosses, stems, necks; design for thin sides with thick bottoms—at no extra cost.

CHOOSE ANY FINISH that's commercially practical. Polish, etch or satin-finish the bare aluminum. Lacquer, paint or lithograph it. Or specify plain or colored Alumilite*, the satiny oxidized finish available only with Aluminum.

MACHINE THE PART to add flanges, inside, outside curl beads, internal or external beads, threads. Parts need less machining, machine faster. You get this saving, too.

GET PARTS ON TIME—Alcoa will deliver completed impact extrusions, ready for finishing, or dependable delivery dates.

*Patented process



Just a request on your letterhead to Alcoa for your free copy of "Alcoa Aluminum Impact Extrusions". Fully explains Alcoa's impact extrusion process and service. Shows whole range of shapes for imagineering.

ALCOA ALUMINUM

IMPACT EXTRUSIONS

From slugs to shapes in split seconds

THESE ALCOA PRODUCTS WERE DEVELOPED IN 62 YEARS' RESEARCH,
PRODUCED BY ADVANCED ALCOA PLANT EQUIPMENT...

Tough Sledding...

A leading ladder-maker's sales weren't climbing like they should. "I have to cut production costs and make a better ladder to boot." He wanted to use magnesium, but heard it rumored that handling it was tough sledding. To find out for himself, he called light metal headquarters, Aluminum Company of America. He learned that fellow-manufacturers were using a million pounds of magnesium every month. That minor changes in shop procedure make handling magnesium easy.* He found that using extruded magnesium parts eliminate most machining. With personal help from Alcoa Engineers, plus books on designing and fabricating he took advantage of magnesium's high strength-weight ratio. His side rails and rungs are extruded by American Magnesium Corporation. His lighter, stronger ladder is stepping ahead of competition.

*No change in insurance rates.

These two free books on magnesium and our broad technical experience can help your products, too. Write Aluminum Company of America, sales agent for American Magnesium Products, 2109B Gulf Bldg., Pittsburgh 19, Pennsylvania.

MAGNESIUM MAZLO PRODUCTS

AMERICAN MAGNESIUM CORPORATION

SUBSIDIARY OF ALUMINUM COMPANY OF AMERICA

THE ALCOA PRODUCTS ADVERTISED ON THESE PAGES ARE BACKED BY ALCOA'S RIGID QUALITY CONTROL . . .

An assembly practice that pays off in Better Aluminum Performance!

WRITE TODAY FOR FREE SAMPLES OF ALCOA ALUMINUM FASTENERS

Aluminum assemblies stay strong and tight when fastened with Alcoa Aluminum Fasteners. No galvanic action between dissimilar metals to loosen up joints. Alcoa Fasteners resist common corrosion, stay bright and attractive, won't red rust-streak adjacent surfaces. Phillips head screws and bolts available—speed assembly, cut rejects, decorate as they fasten.

Standard sizes and lengths, in sheet metal, wood and machine screws, in all popular head styles. Bolts, nuts and washers. Write on your letterhead for samples to ALUMINUM COMPANY OF AMERICA, 2134B Gulf Building, Pittsburgh 19, Pennsylvania.

ALCOA Aluminum FASTENERS

East and Midwest, 2 modern ALCOA PLANTS MAKE the best ALUMINUM DIE CASTINGS you can buy

for example . . .

It's an aluminum die casting, made in one of Alcoa's modern plants. Aluminum, because only aluminum die castings combine all the properties needed. Made by Alcoa, because Alcoa die casting plants turn out sound, on-grade castings at exceptionally low prices.

This scoop holds warmth so ice cream won't stick. It's friendly to food—Alcoa's "218 alloy" won't discolor. Soda jerkers easily wield its feather-weight all day. Yet they can't bend it.

A prompt quotation and engineers handbook available from your local Alcoa sales office. Call there or write ALUMINUM COMPANY OF AMERICA, 1911B Gulf Building, Pittsburgh 19, Pennsylvania.

ALCOA DIE CASTINGS

INGOT • SHEET & PLATE • SHAPES, ROLLED & EXTRUDED • WIRE • ROD • BAR • TUBING • PIPE
SAND, DIE & PERMANENT MOLD CASTINGS • FORGINGS • IMPACT EXTRUSIONS • ELECTRICAL CONDUCTORS • SCREW MACHINE PRODUCTS • FABRICATED PRODUCTS • FASTENERS • FOIL
ALUMINUM POWDERS • MAGNESIUM PRODUCTS

THESE ALCOA SALES OFFICES *Will Aid You*

These sources of the Alcoa products (described on the preceding pages) are as near as your telephone. Let them serve you with engineering help, literature, and a pound or a ton of the Alcoa product that best meets your needs.

ALABAMA
Birmingham—505 First National Bldg.
Phone 4-8593

CALIFORNIA
Los Angeles—108 West 6th Street
Phone Tucker 5121
San Francisco—615 Russ Bldg.
Phone Yukon 6-6484

COLORADO
Denver—524 U. S. National Bank Bldg.
Phone Tabor 4638

CONNECTICUT
Fairfield—1333 Post Road
Phone Fairfield 9-5221
Hartford—Capitol Bldg., 410 Asylum St.
Phone Hartford 5-2192 to 5-2196

DELAWARE
Wilmington—Delaware Trust Bldg.
Phone Wilmington 8-4138 and 8-4139

FLORIDA
Tampa—1004 Tampa Theatre Bldg.
Phone 2-1984
Miami—1129 Alfred I. Du Pont Bldg.
Phone Miami 9-0651

GEORGIA
Atlanta—1800 Rhodes-Haverty Bldg.
Phone Cypress 4681-2-3-4-5

ILLINOIS
Chicago—520 N. Michigan Ave.
Phone Delaware 7-8181
Peoria—415 Commercial Natl. Bank Bldg.
Phone 3-4224 and 3-1784

INDIANA
Fort Wayne—1935 Lincoln Tower
Phone Eastbrook 4676
Indianapolis—817 Merchants Bank Bldg.
Phone Market 2501
South Bend—805 J. M. S. Bldg.
Phone 2-3333

IOWA
Davenport—503 Kahl Bldg.
Phone 2-6243 and 2-6244

KANSAS
Wichita—411 Fourth Natl. Bank Bldg.
Phone 5-6624

KENTUCKY
Louisville—1154 Starks Bldg.
Phone Wabash 7456 and 7457

LOUISIANA
New Orleans—627 Whitney Bank Bldg.
Phone Canal 3372

MARYLAND
Baltimore—400 Baltimore Life Bldg.
Phone Saratoga 8091 to 8094

MASSACHUSETTS
Boston—20 Providence St., Park Square
Phone Hancock 6-2638, 6-2639, 6-2640, 6-2641, and 6-2694
Springfield—507 Tarbell—Watters Bldg.
Phone Springfield 3-5103

MICHIGAN
Detroit—610 New Center Bldg.
Phone Trinity 1-8100
Grand Rapids—812 Michigan Natl. Bank Bldg., Phone Grand Rapids 9-0209
Jackson—1203 National Bank Bldg.
Phone Jackson 2-8206
Pontiac—301 Pontiac State Bank Bldg.
Phone Pontiac 4-1531

MINNESOTA
Minneapolis—1060 Northwestern Bank Bldg., Phone Atlantic 3528

MISSOURI
Kansas City—2300 Power & Light Bldg.
Phone Victor 3870
St. Louis—10th Floor, Continental Bldg.
Phone Franklin 6700

NEW JERSEY
Newark—744 Broad Street
Phone Market 2-6664

NEW YORK
Albany—90 State Street
Phone 4-0146, 4-0147, 6-7489
Buffalo—1880 Elmwood Avenue
Phone Riverside 2880 to 2884
New York—230 Park Avenue
Phone Murray Hill 6-8046 to 6-8058
Rochester—1331 Lincoln Alliance Bank Bldg., Phone Baker 2630
Syracuse—408 State Tower Bldg.
Phone 3-0156

OHIO
Cincinnati—801 Enquirer Bldg.
Phone Parkway 7700
Cleveland—1450 Terminal Tower
Phone Cherry 6880
Columbus—40 South Third Street Bldg.
Phone Adams 5251
Dayton—302 Harries Bldg.
Phone Hemlock 1112
Toledo—1801 Ohio Bldg.
Phone Main 6295

OREGON
Portland—510 The U. S. Natl. Bank Bldg.
Phone Atwater 6605

NORTH CAROLINA
Charlotte—616 Johnston Bldg.
Phone 4-9751

PENNSYLVANIA
Allentown—913 Hamilton Street
Phone Allentown 3-7463 and 3-7464
Philadelphia—123 S. Broad Street
Phone Kingsley 5-0250 to 5-0257
Pittsburgh—2012 Oliver Bldg.
Phone Atlantic 1-4545
York—205 Manufacturers Bldg.
Phone York 2044 and 7441

RHODE ISLAND
Providence—815 Industrial Trust Bldg.
Phone Jackson 1-4108 and 1-4109

TEXAS
Dallas—301 Thomas Bldg.
Phone Riverside 6292
Houston—1806 Commerce Bldg.
Phone Preston 7106

VIRGINIA
Richmond—213 Exchange Bldg.
Phone Richmond 3-8393 and 3-8394

WASHINGTON
Seattle—1411 Fourth Ave. Bldg.
Phone Main 1868

WISCONSIN
Milwaukee—735 N. Water Street
Phone Marquette 8-0185

DISTRICT OF COLUMBIA
Washington—1200 Ring Bldg.
Phone District 9400

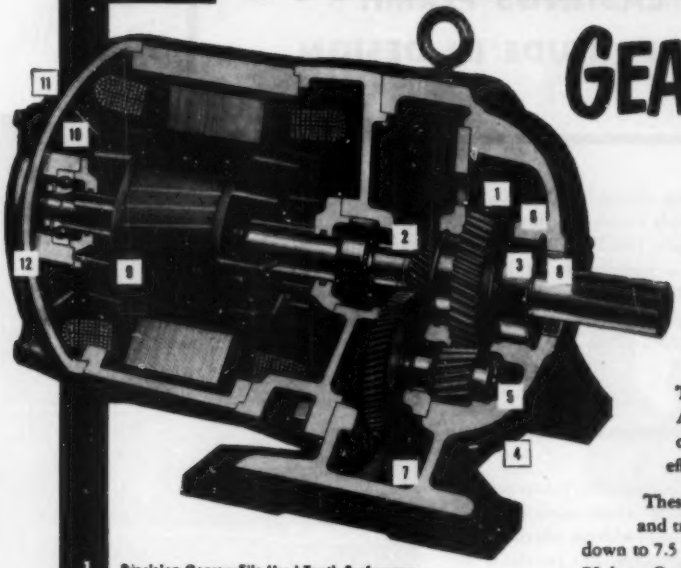
ALCOA FIRST IN **ALUMINUM**

ALCOA ALUMINUM ®

INGOT • SHEET & PLATE • SHAPES, ROLLED & EXTRUDED • WIRE • ROD • BAR • TUBING • PIPE • SAND, DIE & PERMANENT MOLD CASTINGS • FORGINGS • IMPACT EXTRUSIONS
ELECTRICAL CONDUCTORS • SCREW MACHINE PRODUCTS • FABRICATED PRODUCTS • FASTENERS • FOIL • ALUMINUM PIGMENTS • MAGNESIUM PRODUCTS

for BETTER power transmission

FOOTE BROS.-LOUIS ALLIS GEARMOTORS



1 h. p. double reduction unit with output speeds from 230 R. P. M. to 45 R. P. M.

1. Precision Gears—File Hard Tooth Surfaces—Resilient Cores
2. Tang Driven Motor Shaft Pinion provides positive locking without small keyways
3. Extra Capacity Ball or Tapered Roller Bearings
4. Cast Iron Construction for maximum rigidity under load
5. Corner Mounted Offset Shaft—More Compact Design
6. Unit Case with Integral Bearing Housings Maintains Gear Alignment
7. Large Oil Reservoir—Efficient Splash Lubrication
8. Leakproof Oil Seals
9. Dynamically Balanced, Die Cast Aluminum Rotor
10. Impregnated Windings Protect from Moisture, Weak Acids, Alkali, Dust and Oil
11. Cast Iron Housing, Head and Flange Insure Strength and Rigidity
12. Ball Bearing Motor for Trouble-free Operation

The new line of Foote Bros.-Louis Allis Gearmotors offers industry new compactness in design — improved efficiency in operation — longer life.

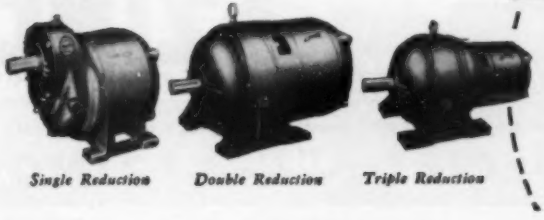
These units are available in single, double and triple reductions, output speeds of 780 down to 7.5 R. P. M., in ratings of 1 h. p. through 75 h. p. Open drip-proof, splash-proof, enclosed and explosion-proof motors are available.

These drives are compact in design with sturdy cast housings, streamlined inside and out. Precision helical gears have file-hard tooth surfaces and tough, resilient cores, giving long-wear life and maximum load carrying capacity. Mail the coupon for bulletin.

FOOTE BROS. GEAR AND MACHINE CORPORATION
Dept. W, 4545 South Western Boulevard • Chicago 9, Illinois

FOOTE BROS.

Better Power Transmission Through Better Gears



Single Reduction *Double Reduction* *Triple Reduction*

Foote Bros. Gear and Machine Corporation
Dept. W 4545 S. Western Blvd., Chicago 9, Illinois

Gentlemen: Please send me a copy of Bulletin AGM with information on Foote Bros.-Louis Allis Gearmotor.

Name.....

Company.....

Address.....

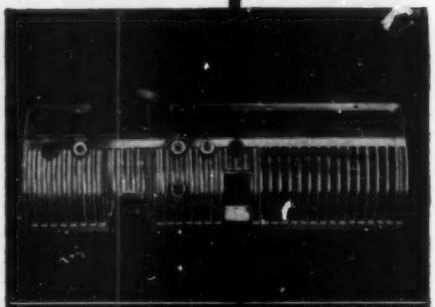
City.....*State*.....

CASTABILITY!

ZINC DIE CASTINGS PERMIT GREATEST LATITUDE IN DESIGN

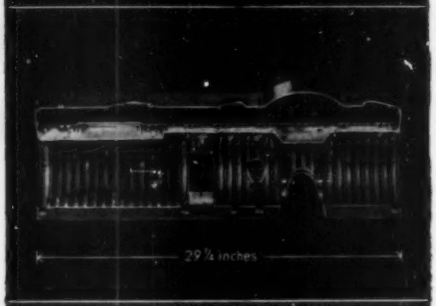
EASE OF CASTING

For proof of the unusual castability of ZINC die casting alloys you need only examine the instrument panel of the 1950 Mercury. This ZINC die casting, beautifully finished in a combination of plating and paint, is an outstanding example of the latitude in design offered to engineers by the "ease of casting" characteristics of ZINC alloys.



LESS METAL USED

Here the casting is shown from the reverse side to reveal the complex coring which minimizes the amount of metal consumed—without affecting the illusion of massive construction. The castability of the ZINC alloy enables transition from thick to thin sections, and facilitates complex shapes, close dimensional limits and surface smoothness.



ONE-PIECE DESIGN

As can be seen in this view of the instrument panel casting on the car, it not only includes the radio grille, it also serves as the frame for the various instruments, operating controls (including the radio pushbuttons), and ash receiver. The names of the various controls are engraved on the casting and all assembly elements are provided on the panel as it comes from the die.

The exceptional castability of ZINC Alloys is just one of the many reasons why ZINC die castings are the most widely used. Every die casting company is equipped to make ZINC die castings and will be glad to discuss their advantages with you. Or write to us.

ZINC
FOR DIE CASTING ALLOYS

The New Jersey Zinc Company, 160 Front Street, New York 7, New York.

The Research was done, the Alloys were developed, and most Die Castings are based on
HORSE HEAD SPECIAL (99.99+% Uniform Quality) ZINC

MR. PRODUCT DESIGNER

Perhaps your company doesn't make or use premiums but isn't there an idea in this success story that applies to your business?

Get in touch with Monsanto today.

We'll gladly work with you.

"We defied habit-itis and three best sellers were born"

says
B. R. Prag
Promotional Mgr.
The Quaker Oats Co.

Sales-winning premiums—Aunt Jemima syrup pitcher, Uncle Mose and Aunt Jemima salt and pepper shakers, Quaker Pitcher Mug—designed and molded of Monsanto LUSTREX styrene by F. & F. Mold & Die Works, Dayton, Ohio for The Quaker Oats Co.

"In the last year we have broken premium sales records with these dramatic new premiums, molded of Monsanto LUSTREX styrene in the image of our famous trade marks."

When The Quaker Oats Company by-passed "habit-thinking" and investigated the advantages of LUSTREX styrene, they found that premiums molded of LUSTREX could be designed to their own specific needs . . . *could* be as distinctive as their own trade marks. They found materials that are *easily* molded—produced with fast mass production techniques . . . materials in a wide range of lustrous, lasting colors that go all the way through and don't fade or peel or chip . . . materials with a lightweight and toughness that reduce mailing charges and breakage losses. Best of all, they learned that consumers are pre-sold on Monsanto Plastics, and on products made from them.

Hundreds of manufacturers are finding that the versatile properties of LUSTREX and other Monsanto Plastics make them especially suited to their products—whether they may be premiums of normally distributed consumer goods, or industrial applications.

Perhaps in looking over *your* products you'll find ways to improve them—and ways to produce them at lower cost—with plastics. You'll want to investigate the remarkable properties of the many plastics in Monsanto's broad line. The coupon is for your convenience.

MONSANTO
CHEMICALS—PLASTICS

SERVING INDUSTRY . . .
WHICH SERVES MANKIND

MONSANTO CHEMICAL COMPANY
Plastics Division, Dept. PEP-26, Springfield 1, Mass.
Please send me "What Monsanto Plastics Can Do For You."
Name _____ Title _____
Company _____
Products Manufactured _____
Address _____
City _____ Zone _____ State _____

ANEMOSTAT

—famous for AIR DISTRIBUTION

SAVES WITH SPEED NUTS

—famous for COST REDUCTION

A multiple-function Tinnerman fastener replaces 3 parts, eliminates 6 assembly operations, and saves thousands of dollars annually.

That, briefly, sums up the experience that led Anemostat Corporation of America, New York, to switch to SPEED NUTS. This decision was the end result of a recent review of production and assembly costs on their draftless air diffusers.

Cost of the previous assembly method was compared with the new SPEED NUT method. As a result, *SPEED NUTS were specified, and are currently producing 50% lower material costs and substantial assembly savings.*

What about your product . . . isn't there a fastening job that multiple-function SPEED NUT brand fasteners can do better, more economically? Find out NOW. Also, write for your copy of "SPEED NUT Savings Stories". TINNERMAN PRODUCTS, INC., 2040 Fulton Road, Cleveland 13, Ohio. In Canada: Dominion Fasteners Limited, Hamilton.

OLD METHOD
SPEED NUT METHOD
Previous method of assembling fixing stay on diffuser, using five parts: Machined metal block was riveted to back of top louvre with two rivets. Shoe supporting stay was then attached by screw.
SPEED NUT method, using three parts: Special SPEED NUT is snapped into position by hand, screw is driven through shoe for fixing stay and—presto—a vibration-proof attachment! Fewer parts to handle, faster, easier assembly.
TINNERMAN
Speed Nut

Risks Are a Part of Progress

IN OUR TRAVELS THROUGH LIFE we are faced with the choice of sticking to the finished paths and highways, or striking out over the rough and rugged roads, or standing still. The last, which is the same as doing nothing or drifting, ironically presents the greatest danger. There is no safety in stagnation. As a nation, we drifted along when Japan moved into Manchuria, when Italy overran Ethiopia, when Hitler began spreading over Europe. Similarly, stagnation in product development builds up the strength and dominion of competitors.

Picking out the easy to travel well worn paths is likewise dangerous, though the going itself may be safe. It is the kind of a road that too many take because it is so alluring. The going is smugly comfortable, the passing scenery is soothingly attractive, and the speed is fast. Everything contributes to a feeling of self satisfaction.

Unfortunately, self satisfaction has never created anything. Nor has anyone ever done anything worthwhile without risk. All our progress has come from men who had not only vision and creative power but also grim determination and courage. They accepted the risks of travelling the unfinished roads in seeking to bring to fulfillment the promise of unfinished developments.

Of course the road under construction is full of risks. Troubles and confusions are many because of no signs, signals or guard rails. Hardships, frustrations, trials and tribulations are abundant. Many impediments at first glance appear unsurmountable. Warnings read, "Travel At Your Own Risk." But when the goal is reached and the determined efforts meet with success, the reward is not a commonplace trifle but a monumental creation.

Designs that are merely another version of a well worn concept and new models that have but minor refinements of details are but commonplace products that vie with each other from scratch in the race for the purchasers' dollar. Products that are genuinely new in the possession of previously unattained desired features, devices and mechanisms, that bespeak the vision and courage of their designers possess a distinction that is reflected in public acclaim. To create such products involves many trials and tribulations. The risks of failure are ever present and the going is sometimes rough. Only a mind that is insensitive to risk and is spurred on by a creative commitment can travel the rough and rugged road and reach the desired goal and thereby achieve progress.

G. F. Zodenholt

Take a look at something wonderful YOU CAN'T SEE!

When you examine and admire the new models at the winter shows, you'll see many of the devices that make automobiles so dependable today. But not all of them!

You can't see the amazingly accurate New Departure ball bearings beneath the gleaming chrome and lacquer of the new cars. Located where they are, by engineers who perform new "miracles" each year, these *ball* bearings carry the loads, lick wear and friction, and keep moving parts moving, precisely in position, for years and years.

New Departure, world's largest maker of ball bearings, welcomes the increasing acceptance by engineers of the fact that "nothing rolls like a ball."

nothing rolls like a ball...

NEW DEPARTURE
BALL BEARINGS

89 NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT

Fast response, high amplification, and low power losses are some of the advantages of . . .

D-C Control With Amplistats

How the amplistat—a reactor and rectifier—can be used for d-c power control. Inherent advantages and applications. Comparisons with other d-c devices, including hard tube amplifiers, rotating machines, and thyratrons.

W. L. O. GRAVES
Controls Division

H. M. OGLE
General Engineering and Consulting Laboratory
General Electric Company

SELECTION OF D-C POWER CONTROLS is not always a simple task. It involves the consideration of many factors—rate of response, amount of input current, matching of input impedances, wave shape of the ouput current, and ease of maintenance, among others. Often there are conflicting requirements, with the result that commonly used power control devices such as hard tube amplifiers, thyratrons, saturable core reactors, or amplidynes do not exactly fit the applications. In such cases, the designer would do well to consider the amplistat.

The amplistat, Fig. 1, consists of a saturable core reactor and a rectifier, usually of the selenium or germanium crystal type. The saturable core reactor is a device somewhat resembling a transformer: It consists of several windings on a laminated iron core, but differs from the transformer in that the core is designed to be operated in the region of magnetic saturation.

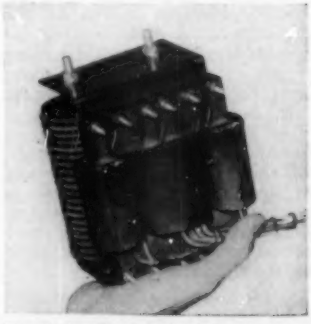


Fig. 1—Amplistat with 100 watt rating. The saturable core reactors (front) and the dry plate rectifiers (rear) are compactly mounted, and the entire device often can be located adjacent to the load to minimize line drops due to long leads.

Operation of the amplistat can be best understood by a study of an elementary amplistat as shown in Fig. 2. The a-c winding on the saturable core and the rectifier is connected in series with the load. An alternating voltage is applied to the circuit. During the first half-cycle, the rectifier blocks the current in the circuit. During the first part of the next half-cycle current is limited by the inductance of the saturable core reactor.

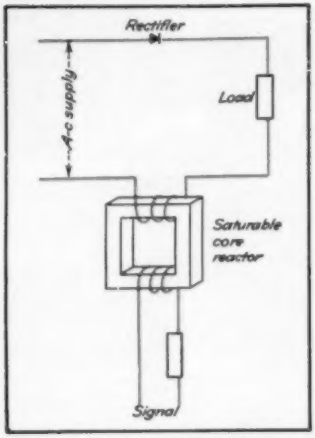


Fig. 2—Schematic circuit of elementary amplistat. Small signal currents control large load currents. Another way of looking at it is that a small signal current is amplified to a large load current.

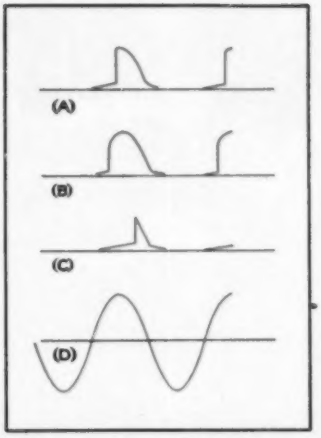


Fig. 3—Wave shapes of the load current (A) when the signal current is small; (B) when the signal current has a large positive value; (C) when the signal current has a large negative value.

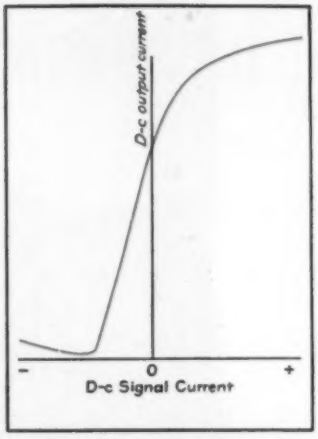


Fig. 4—Typical amplistat control characteristic showing the effect of the signal current on the output current. The operating range generally is in the range of maximum slope of the curve.

As the current builds up in the circuit, more and more flux is induced in the core. When the core becomes saturated, the inductance of the reactor drops to a very small value and the current is limited only by the load impedance. The current is usually great enough to keep the core saturated for the remainder of the half-cycle. During the subsequent half-cycle (when the line voltage reverses) the flux in the core collapses. The rectifier then blocks the current in the circuit until the line voltage again reverses.

As any given core can store only a definite amount of flux, flux from any other source will influence the "firing point" (time during the cycle when the core saturates). This controlling flux is usually obtained from a signal winding through which a d-c signal current is passed. By controlling the d-c signal current, it is possible to set the load current at any value between minimum and maximum. In other words, the strength of the d-c signal and the point at which it is applied governs the amount of load current.

The actual values of the signal current for any particular amplistat depend on its design. As shown in Fig. 3, the wave shape of the current flow changes with a change in the amount of signal current. In any case, only a relatively small signal flux is required to control the amplistat, and it is possible to use a signal winding having a small number of turns. In this way, the inductance of the signal winding may be kept low and fast response can be obtained.

An amplistat is an amplifier by virtue of the fact that a small amount of power in the signal winding controls (or modulates) a larger amount of power in the load windings. So also is a saturable core reactor an amplifier, except that in such a device the ratio between load current and signal current is smaller (low "amplification") and there is a longer time delay between a change in the signal current and a corresponding change in the load current (slow rate of response).

A typical amplistat control characteristic is shown in Fig. 4. The minimum current of the amplistat can be considered similar to the exciting current of a transformer. It represents complete unsaturation of the core, and is therefore the point at which there is the highest impedance to current flow. Of course, an amplistat can be operated within any values of signal current, but it usually is operated in the region of the highest gain, that is, in the range of signal current values for which the curve has the highest slope.

Advantages and Limitations

Some of the major advantages of the amplistat are apparent from the previous description of its operation; others are not so readily brought out:

1. It is a static device and therefore not so susceptible to damage by vibration and shock as are some of the other types of power amplifiers. Also, it usually requires less maintenance than rotating equipment, the bearings and commutator of which must have periodic overhaul.

2. Since the amplistat requires no warm-up period, it can be placed in operation within about one-half cycle of the power supply frequency. In some applications, notably aircraft, a short time delay is imperative. In comparison, rotating equipment may take up to 5 seconds to get up to speed, and thyratrons and vacuum tubes need 2 to 15 seconds or longer. To minimize this delay when hard tube amplifiers are used, power often is continuously supplied to the tube filaments, which necessitates some stand-by power capacity.

3. It is readily matched to any input impedance; aging of the rectifier is unimportant if the amplistat is properly applied.

4. The input is electrically isolated from the rest of the circuit, with the result that the input winding may be insulated to withstand up to 10,000 volts, or higher and the rest of the windings may be grounded. This avoids the need for isolating the circuits. While rotating machines also possess this inherent advantage, vacuum tubes definitely do not.

5. It has low power loss and consequently, a high operating efficiency. Since it controls the current by a

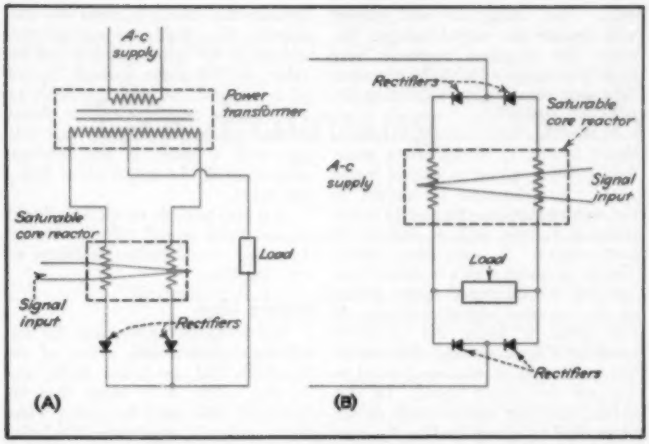


Fig. 5—Two basic amplistat circuits: (A) the center tap amplistat, which is used if it is necessary to ground one end of the load; and (B) the bridge type amplistat, which is the less costly and more satisfactory with an inductive load. Both circuits utilize a pair of saturable cores. In smaller sizes, those circuits are comparable in cost, but in larger sizes, the bridge circuit is less expensive and is generally used.

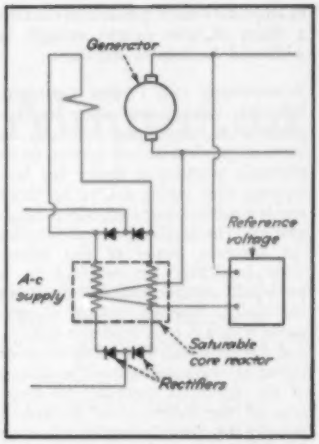


Fig. 6—Voltage regulator. The difference between the generator output voltage and a reference voltage is applied to the signal winding of an amplistat, which controls the field current to the generator.

phase shift, it has no inherent resistive loss or heating power loss as do vacuum tubes, nor any mechanical losses, as do rotating equipment.

6. It is easy to mount. Vacuum tubes, in comparison, often must be mounted in the vertical position and frequently require special shock mounting, whereas an amplidyne needs some sort of mounting plate on base.

7. It may be designed to handle very large amounts of power with a very small input. In one installation, the input power was only 10^{-10} watts, with a maximum current input of 100 microamps. With a two stage amplistat, the input was amplified linearly to actuate a 5 milli-ampere meter. With additional stages, the output can be raised to kilowatts.

8. Finally, the cost of the amplistat is comparable to that of other power amplifying devices.

As indicated in Fig. 3, the output of the amplistat is pulsed d-c. In some applications—such as those used to take-over the control of equipment on an automatic basis—this is very undesirable. If it is necessary to have an output current that reverses its polarity, considerable complexity must be added to the circuit, sometimes greatly lowering the circuit efficiency. Usually the amplistat is used in circuits where a single polarity of output current is wanted. In Fig. 5 circuits of this type are shown.

The difference between the two circuits shown in Fig. 5, one a center tap amplistat and the other a bridge type amplistat, is that the center tap device requires a power transformer with a mid-tap secondary. On the other hand, it uses only two rectifiers as compared to the four required for the bridge type. In smaller sizes, both types are comparable in cost, but in medium and large sizes, the bridge type amplistat is considerably less costly. For this reason, plus the fact that the bridge type unit operates more satisfactorily with an inductive load, it generally is specified. However, with the bridge unit, the load is tied directly to the supply line, and it is impossible to ground one end of the load without adding a transformer.

Both of these circuits require a pair of saturable cores. This arrangement is preferred in most amplistat circuits because the voltage induced in the signal winding by one core tends to cancel the voltage induced by the other core. Frequently the cores are placed close together and one signal winding is used to link both cores.

Typical Applications

The principal applications for amplistats can be broken down into three categories: (1) To amplify small amounts of power into measurable quantities, as, for example, the outputs from d-c strain gage circuits, potentiometers, photocells, thermocouples, and d-c shunts; (2) to control large amounts of power from small power inputs, as when applied to motor or generator fields; or (3) to isolate branches of control and power circuits.

AMPLIFICATION OF SMALL POWER INPUTS. Although amplification of the unbalance in bridge circuits or of the output from potentiometers and thermocouples is by now a more or less accepted application for amplistats, some of these devices are quite unusual. One possible use of an amplistat is as an amplifier in a strain gage circuit on a power shovel. The output from the strain gage is proportional to the deflection of the boom. This output then is amplified and measured directly on a calibrated meter in the cab to indicate the beam loading and enable the operator to keep loading within safe limits.

Another application is a flame detector for a locomotive gas turbine. This device consists of a radiation-type thermopile having an output of approximately 10 micro-watts, and a two-stage cascaded amplistat that raises the power level to operate a sensitive relay. Each amplistat is about a two-and-one-half-inch cube and has an eleven-terminal plug-in base to facilitate removal and replacement. Each unit contains two amplistats to provide both forward and reverse polarity operation, and is capable of a power gain of better than 100. The power supply frequency is 400 cycles. Mainly through the use

of amplistats was it possible to develop a flame detector rugged enough to withstand locomotive service.

POSITIONING AND POWER CONTROL DEVICES. Amplistats also are applicable as amplifying elements in servo-mechanism control devices. In an electrode positioning device for hot-topping steel ingots, a 1/12 hp shunt motor positions the electrode through gearing. The amplistat system supplies the armature power of this motor. Two amplistats are required in a push-pull combination for reversing the motor. The arc voltage is compared with a pre-set reference voltage, and the difference is used as an error signal in the amplistats. The output of the amplistats energizes the armature of the shunt motor in such a polarity so that the motor raises or lowers the electrode so as to reduce the error voltage. This provides a modulating system for positioning the electrode. By regulating the arc voltage, the amount of heat generated and thus the process, is controlled.

A simple voltage regulator, Fig. 6, such as might be used on an arc welding machine, induction heating generator, or engine-driven power generator, also provides a good illustration of how the amplistat can be applied. The output voltage of the generator is compared with a reference voltage and the difference applied to the signal winding of the amplistat. The output of the amplistat supplies the field excitation for the generator. Any small change in output voltage of the generator causes a large change in the generator field. This change in field current will regulate the output voltage. Because the amplistat responds very rapidly as compared with the generator field time constant, no stabilizing circuits are required.

A similar field control circuit is shown in Fig. 7. In this case a motor field is being varied to control motor speed. A tachometer is coupled to the motor to measure its speed (motor armature voltage, with or without *IR* compensation is sometimes used). This is compared with a reference voltage and the difference again applied to an amplistat signal winding. If the motor is under the called-for speed by a small amount, the field of the motor will be weakened so as to increase the motor speed. In this circuit, auxiliary means (such as the series field as shown in Fig. 7) must be provided for starting the motor.

Another motor speed control is shown in Fig. 8. In this case the amplistat supplies the full armature power to the motor. A very wide speed range is possible with this type of control. Although Fig. 8 shows a separately excited motor, a series motor is frequently used in this type of circuit. The center tap amplistat circuit or any of several three-phase amplistat circuits could also be used in this speed control or for either of the other circuits shown in the previous illustrations.

ELECTRICAL ISOLATION. Applications of amplistats are being made to circuits in which isolation—not amplification—is the primary objective. In one recent case, it was desired to measure the voltage between two conductors. One conductor was approximately 20 KV above ground, and the other, 10 KV above ground. By use of a potential coil and a suitable resistor in the amplistat control circuit, it was possible to measure this voltage with a meter in the amplistat output circuit, the output circuit being grounded.

It is also possible to add or subtract signals from several different sources by using several contact windings on one amplistat.

Future Uses

The foregoing applications for amplistats represent only a few of the hundreds that are being made, and in the future it is likely that the amplistat will come into even wider use as industrial amplifiers. It is being applied on a large scale in the industrial field, present or future applications being to regulate the speed of steel mill motors; to regulate the speed of large motors for such uses as variable speed printing press drives; and innumerable others. For applications that call for high gain, fast response, a high degree of reliability, and static components, the amplistat will be the answer. In addition to such d-c applications, the device may be adapted for a-c operation. As a matter of fact, several units have been designed for a-c use with very interesting and successful results. But, while it is yet too early to predict with finality, it seems likely that the amplistat will remain primarily a d-c power control device, with a-c applications being in the "special" category.

Fig. 7—Motor speed control utilizing an amplistat to control the motor field. If the motor speed is under that which is required, the drop in voltage differential weakens the motor field and the speed increases.

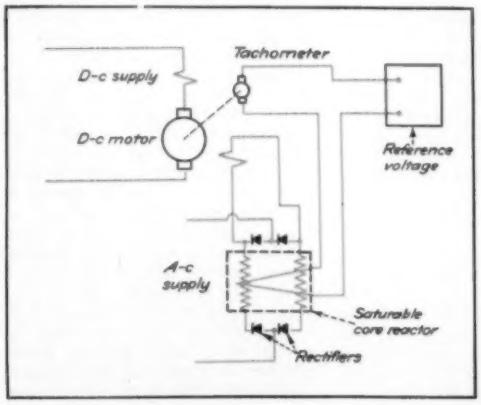
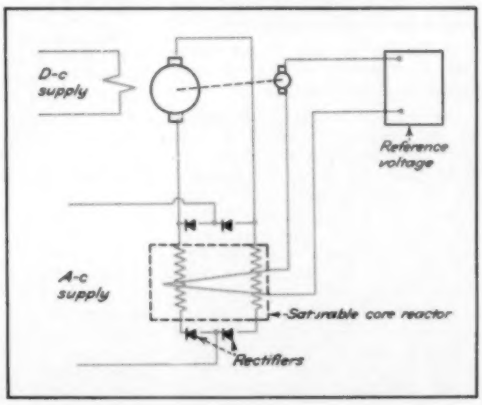


Fig. 8—Another speed control circuit, the advantage of which is a wide range of control. In this case, the amplistat controls the full armature voltage. Three phase amplistats also are suitable for speed control and similar applications.



Resistance Heating for . . . .

Hot Forming 75S-T6 Aluminum

A. L. SCHOELLERMAN
Process Engineering Department, Northrop Aircraft, Inc.

Resistance heating has recently been shown to be rapid and efficient when used for hot forming of high strength 75S-T6 aluminum alloy. In a test program, Northrop engineers have attempted to determine which of two resistance heating methods would give most satisfactory production. In evaluating the two types, the effect of time and temperature on physical properties, heating time versus cross-sectional area, and methods of temperature control were investigated.

THE ADVENT OF HIGH STRENGTH, heat treatable aluminum alloys brought with it serious problems of forming and heat treating. When the parts were formed before heat treating relief of induced stresses during heat treating, as well as non-uniform cooling afterward, resulted in serious warpage and dimensional changes. To correct the distorted shapes, mechanical straightening and makeshift shop practices were used. These in turn caused indeterminate prestressing, reduced physicals, and overburdening of production facilities to an extent that output was retarded.

One possible solution of the problem was to form the parts after heat treatment. But because the heat treated aluminum alloys could not be formed at room temperature, hot forming would be necessary. The important advantages of this method are: (1) Hot forming in the heat treated condition requires only one operation, but when annealed several operations at room temperature are necessary; and (2) elimination of heat treatment reduces time of parts in the fabrication department. This improves scheduling.

The technical problem in hot forming was to maintain a critical temperature range. The forming temperature would have to be low enough so that there would be no adverse effect on the strength properties of the finished part because of annealing. However, if the temperature fell too low, through cooling, the parts could not be formed properly. For 75S-T, the most generally used of the high strength heat treatable aluminum alloys, a temperature of 300 F appears to have no effect on strength. At 400 F appreciable annealing takes place.

It was found that excellent results by hot forming method could be obtained on 75S aluminum alloy in the heat treated or full hard condition because of its improved ductility at elevated temperatures. The forming limits (ductility) of 75S-T6 at 300 F compares favorably with 75S-0 at room temperature under certain conditions of forming, i.e., stretch forming.

Because temperature is a critical factor, methods that permit uniform heating throughout the mass of the part are necessary. Conventional furnace heating methods were unsatisfactory, since the time involved in heating is lengthy, methods of handling are clumsy, and it is impractical to control the temperature within the limits required. Induction heating could not be used; because of the rapidity of heating adequate temperature control could not be maintained. Resistance heating then appeared to offer greatest promise. With this method the heat developed would be uniform throughout the part, except where there were severe variations in size and shape of the cross section.

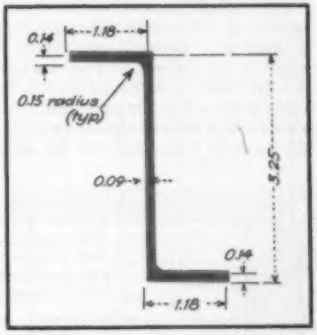


Fig. 1—Zee extrusions of 75S-T material used in determining comparative physical properties. All dimensions are in inches.

To determine the optimum temperature to which the part should be

Table I—Physical Properties of Resistance Heated 75S-T Specimens

Heating Conditions	Range of Thicknesses, in.	Average Yield Point (2% offset), psi	Average Ultimate Strength, psi	Average Elongation in 2 in., percent
d-c equipment, to 300 F	0.098 to 0.139	77,100	86,600	13.4
a-c equipment to 300 F	0.098 to 0.139	78,100	88,600	13.0
d-c equipment, to 400 F	0.098 to 0.149	73,700	82,400	10.3
a-c equipment, to 400 F	0.099 to 0.139	72,600	81,300	10.5
Control Specimens (no heating) from random stock	0.099 to 0.138	77,600	86,400	12.6

Table II—Minimum Tensile Strength Specifications for 75S-T Extrusions

Thickness, in.	Yield Point, 1,000 psi	Ultimate Strength, 1,000 psi	Elongation in 2 in., percent
up to 0.249	70	78	7
0.250–2.999	72	80	7
3.000–4.499 (20 sq in. max. cross section)	70	80	7

heated by resistance heating, extensive tests were conducted by Northrop Aircraft, Inc., using heating equipment furnished by Sciaky Bros., Inc. A secondary objective of this investigation was to evaluate the realm of efficiency of single phase a-c and tri-phase pulsating d-c equipment.

Effect on Mechanical Properties

For test purposes, Z section 75S-T extrusions of dimensions shown in Fig. 1 were used as specimens. Table I presents the physical properties when the extrusions were heated to 300 F, using either a-c or d-c equipment. As shown, there were no significant physical property losses nor did the final physicals of the material fall below the minimum standards shown in Table II, which presents the material specification standards of Northrop Aircraft. It should be mentioned, however, that the values presented in Table I are those after the material has been heated only once. Repeated re-heating of the 75S-T material will successively reduce the physical properties, because the annealing effects are cumulative.

Heating 75S-T in the hardened condition to 400 F produces substantial physical property losses. Using a-c equipment, there was a loss of approximately 6 percent in ultimate and tensile yield; with d-c equipment, this loss was about 5 percent.

The greater losses in using a-c at 400 F, as compared with the low frequency pulsating d-c equipment, might be explained by the rapid change in polarity of the applied voltage which causes loss in temperature control or the actual variation in one method over the other method is within the error of the experiment.

Location of the extrusion to be heated with respect to the magnetic field has a definite effect on the uniformity of heating; hence on the uniformity of mechanical properties. Extrusions of various shapes heat evenly unless the extremeties are rather thin. By experimenting with extrusions of different shape, it was determined that a satisfactory heat gradient could be obtained by locating the thickest part of the extrusion within the inductive loop formed by the buss-bar and the piece, and keeping the thinnest section away from the loop. Other factors affecting uniformity include surface area, room temperature, voltage and length of part.

Effect of Temperature And Heating Method

In addition to determining the effect of resistance heating on the physical properties of the material, the relative effects of a-c and d-c methods, as well as different temperatures, were also investigated.

The a-c equipment consisted of a single phase, 60 cycle a-c transformer, rated at approximately 40 kva; a phase shift control was used ahead of the transformer to control the primary voltage. The d-c equipment included a tri-phase transformer rated at approximately 75 kva, and ahead of the transformer a panel that controlled phase shift, rate of d-c pulses per sec and off time between pulses.

Although 300 F was the proposed allowable temperature for production heating of parts, the tests were also

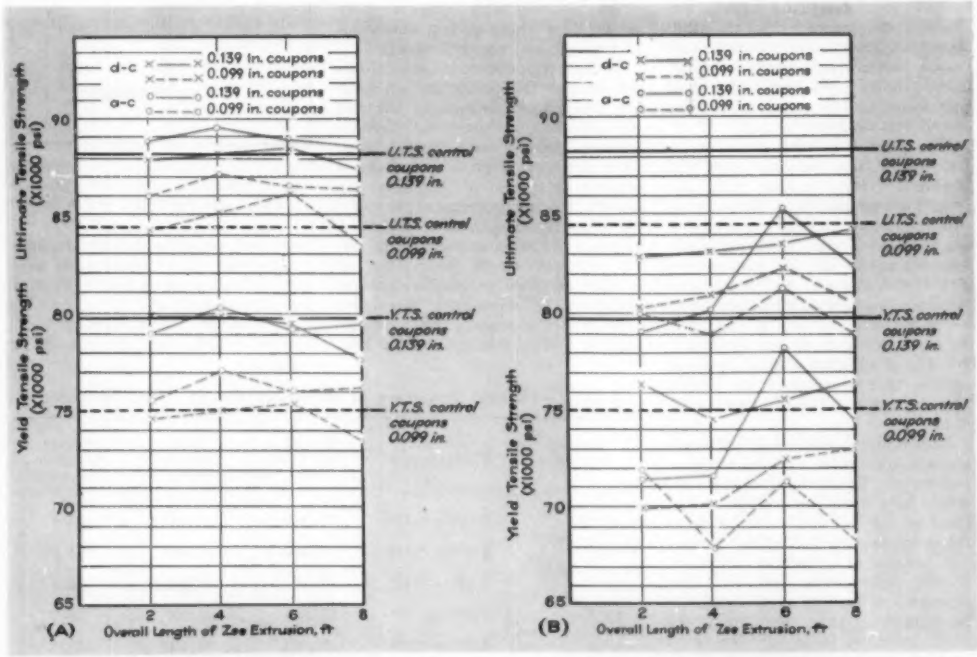


Fig. 2—Effect of extrusion length on physical property changes caused by resistance heating on a-c and d-c equipment at (A) 300 F, and (B) 400 F. Points on the graphs were obtained by averaging three values, except for the 2 ft extrusion lengths.

run at 400 F, to accentuate any difference between results produced by a-c and d-c equipment. To control temperature, a color-change lacquer was used at 300 F; in the series of tests at 400 F, electrical recorders were used in addition to the temperature-indicating lacquers.

The sharpest difference in property results caused by heating at 300 F and 400 F can be seen in the elongation values. Heating the extrusion to 300 F produced an average gain of 4.75 percent over the control values; yet there was an average loss of 14.2 percent in elongation when heated to 400 F by either method. This can be attributed to the stress relieving action that takes place without over-aging at 300 F, resulting in an increase in elongation at room temperature. At 400 F, over-aging or coalescence of the age-hardening precipitate occurs, lowering the tensile properties but also causing a decrease in elongation.

With special reference to part length, Fig. 2 shows these physical property results by means of curves, for two selected thicknesses, and various heating conditions.

The time required to bring an extrusion to the maximum allowable temperature is a direct function of cross-sectional area of the extrusion, area of the inductive loop, magnitude of current flow and power factor. Fig. 3 shows the comparative curves of heating time vs length of part for a-c and d-c equipment in resistance heating to 300 F and 400 F. However, greater flexibility of the a-c setup is demonstrated in Fig. 4, which shows curves of power input vs. phase shift control settings. By phase shift control, greater speed of heating can be obtained if needed. This is desirable when heating extrusions of odd lengths and special shapes.

An important problem in resistance heating was local overheating of the part of the point of contact. This was overcome by using the solid copper buss-bar, which conducted the secondary current from the transformer, as the area of contact and as support for the extrusions to be heated. When the extrusions were of odd shape, as the hat section in Fig. 5, copper dies conforming to the part were used with successful results.

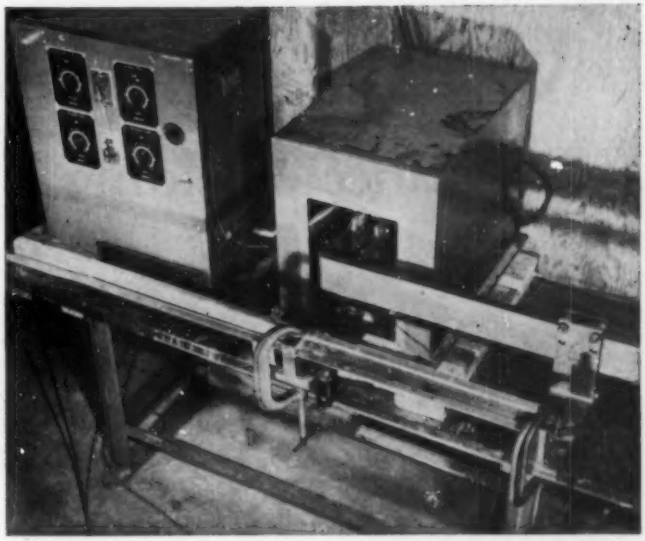


Fig. 5—Copper buss-bar and copper dies conforming to the shape of the part increase flexibility of the resistance heating method, by allowing odd shapes to be heated.

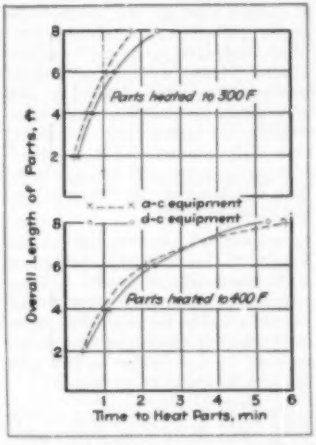


Fig. 3—Comparison of length of part and heating time in resistance heating of 75ST zee extrusions, using a-c and pulsating d-c equipment.

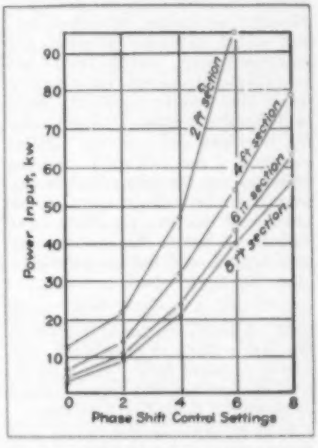


Fig. 4—Phase shift control allows greater flexibility of heating in a-c method. This is especially valuable when forming odd lengths and shapes.

Flexibility

Parts of various lengths could be heated by sliding one contact throughout the length of the bar. Where greater flexibility was needed, small lengths of water-cooled flexible cable could be attached directly to the buss-bar. These heavy buss-bars suggest using portable small transformers (5 to 15 kva) to efficiently heat small extrusions, thus making it possible to hot form small parts anywhere in the shop, or in the field.

Conclusions

In analysis of the foregoing results the following conclusions can be drawn:

1. The pulsating d-c current shows slight advantage in minimizing loss of physical properties in 75S-T6 aluminum alloy at elevated temperatures.

2. The inductive loop is only slightly less critical in the use of the pulsating d-c than in alternating current.

3. Since metallurgical properties are practically the same, and there does not appear to be any variation in the uniformity of heating odd shapes by each method, the greatest difference arises when comparing the capital investment and installation costs.

Weldability of Metals By Resistance Welding Techniques

WALLACE A. STANLEY
Director of Production Design, Progressive Welder Company

Suitability of metals, alloys, and plated materials for spot, projection, flash, butt, and seam welding. General precautions, and thickness and shape limitations. Taken from the author's forthcoming book "Resistance Welding" to be published by the McGraw-Hill Book Company

A COMPLETE DISSERTATION on all the metals and metal alloys that are weldable by resistance welding methods would be very extensive. Besides discussing the weldability of steel, aluminum, brass, copper, galvanized iron, lead, nickel, nichrome, tin plate, zinc, phospher-bronze, nickel silver and scores of other metals and alloys, it would also have to explain the effect of different techniques, different welding machines and controls, different electrodes, and different welding schedules on the joint. Such a dissertation is beyond the scope of this article, the purpose of which is to indicate the metals that can be resistance welded, and the general limitations that are involved.

LOW CARBON STEEL. The metals most commonly resistance welded are low carbon steels in plate, sheet, rod, wire or extruded form. These are defined as steels having a carbon content of between 0.10 and 0.15 percent.

Products made of low carbon steel may be spot welded in thicknesses of plates and sheets from 0.001 to 1.0 in., or seam welded in thicknesses of from 0.001 to about $\frac{3}{8}$ in. Difficulty is experienced, however, in seam welding sheets or plates in the upper size ranges due to the tremendous amounts of electrical energy required, and seam and spot welding are not ordinarily adaptable to the resistance welding of rod or wire.

Projection welding is satisfactory for parts ranging from 0.010 to $\frac{1}{2}$ in. in thickness, and for wire and rod in sizes of from 0.002 in. to 1.0 in. in diameter. Also, low carbon steel products of from 0.015 to 0.40 in. thick may be flash welded with proper equipment; in some instances, flash welding of steel bars as big as 10 in. in diameter has been accomplished with special machines.

STAINLESS STEELS. Stainless steels are readily welded due to their high electrical resistance and the resultant lower requirements of current. Greater electrode pressure is required in spot and projection welding than when welding low carbon steels; a welding interval is recommended to avoid carbide precipitation; and precise control must be exercised. Synchronous control is recommended.

LOW ALLOY AND TRADE NAME STEELS. Many well known special steel alloys require special welding techniques due to hardening of constituent alloys in the steel. Because of this hardening, sequencing controls are required in the welder so that post heat-treatment can be performed.

HEAT TREATABLE STEELS. Special alloy steels as well as high carbon steels can be easily welded provided that a special type of heat-treatment is performed immediately after welding. Such post heat-treatments often can be done in the welding machine by the application of lower values of welding current in a predetermined sequence and with a predetermined length of current application.

Of course, many alloy steels cannot be heat-treated in the welding machines due to their tendency to crack on rapid cooling, or to the excessively long tempering time required by certain alloys. Parts having a high-speed steel section flash-welded to a low alloy section are in this category, and are usually removed to a furnace for heat-treatment and restoration to room temperature.

STAINLESS STEEL WELDED TO CARBON STEELS. As has been previously explained, stainless steels have a much greater electrical resistance than carbon steel and therefore tend to heat much more quickly. Often resistance ratios are on the order of 8 to 1. To compensate for this difference in rate of rise to welding temperature, special techniques must be employed, as explained in detail under welding of dissimilar metals.

ALUMINUM AND ALUMINUM ALLOYS. Aluminum and aluminum alloys have been extensively welded by the spot, seam, and flash-butt welding processes. Little success has been achieved, however, in projection welding of aluminum because the projection usually collapses under pressure before the welding current has raised it to welding temperature. An extremely fast welding cycle is imperative.

A more exacting type of welding control and lower inertia welding ram are required for aluminum and aluminum alloys than are generally used with mild steel. There are several fundamental reasons for this. Aluminum has a narrow plastic range and requires an accurate and precise welding control to avoid complete melting. Aluminum also has high electrical and thermal conductivities, and very low contact resistance. Due to the narrow plastic range and the precise timing required, rapid "follow-up" of the moving tip on the spot weld is essential and can only be accomplished by minimizing friction and inertia on the moving tip.

The most annoying characteristic

Table I—General Weldability of Metals for Resistance Welding

Metals	Aluminum	Stainless Steel	Brass	Copper	Galvanized Iron	Steel	Monel	Nickel	Nichrome	Tin Plate	Zinc	Phosphor Bronze	Nickel Silver	Terneplate
Aluminum	B	E	D	E	C	D	D	D	D	C	C	C	F	C
Stainless Steel	F	A	E	E	B	A	C	C	C	B	F	D	D	B
Brass	D	E	C	D	D	D	C	C	C	D	E	C	C	D
Copper	E	E	D	F	E	E	D	D	D	E	E	C	C	E
Galvanized Iron	C	B	D	E	B	B	C	C	C	B	C	D	E	B
Steel	D	A	D	E	B	A	C	C	C	B	F	C	D	A
Lead	E	F	F	E	D	E	E	E	E		C	E	E	D
Monel	D	C	C	D	C	C	A	B	B	C	F	C	B	C
Nickel	D	C	C	D	C	C	B	A	B	C	F	C	B	C
Nichrome	D	C	C	D	C	C	B	B	A	C	F	C	B	C
Tin Plate	C	B	D	E	B	B	C	C	C	C	C	D	D	C
Zinc	C	F	E	E	C	F	F	F	F	C	C	D	F	C
Phosphor Bronze	C	D	C	C	D	C	C	C	D	D	D	B	B	D
Nickel Silver	F	D	C	C	E	D	B	B	B	D	F	B	A	D
Terneplate	C	B	D	E	B	A	C	C	C	C	C	C	D	B

A—Excellent; B—Good; C—Fair; D—Poor; E—Very poor; and F—Impractical.

encountered in the welding of aluminum is the film of oxide inherently deposited on aluminum under ordinary exposure to the atmosphere, which tends to build up a high electrical resistance when welding. This oxide must be removed either by mechanical or chemical means within three to five hours before spot or seam welding, else it results not only in inconsistent welds, pickup on the welding electrodes, and an impossible welding condition within a brief time after the first weld, but also in welds having poor metallurgical and strength qualities. Surface preparation is not as critical for flash welding.

BRASS. Resistance welding processes can be used on nearly all of the brasses except those high in lead content; in this latter type, brittle welds result. Brass should be cleaned before welding because the oxides create varying contact resistance between the electrodes. These oxides are complex and do not easily break down to permit the passage of welding current between the two surfaces.

The welding current must be accurately controlled, inasmuch as an excessive welding time often vaporizes a large amount of zinc from the zinc bearing alloys, causing a change in the properties of the material in the weld area. The current requirement is greater than that needed for steel, but a lower electrode pressure and a shorter welding time is required. In some special grades, high electrode pressure causes cracking in the zone adjacent to the weld.

Brasses may be projection welded in thicknesses ranging from 0.010 to $\frac{1}{16}$ in. Seam welding is practical in thicknesses ranging from 0.001 in. to about $\frac{1}{16}$ in. Flash-butt or upset-butt welding is practical for brass rods from 0.005 in. diameter to approximately 2 in. diameter. The range of thicknesses for spot welding brass is between 0.005 in. and $\frac{1}{4}$ in; thicknesses in excess of $\frac{1}{4}$ in. require large machines and excessive currents.

BRONZE. Most of the bronzes can be resistance welded except those containing lead and some containing excessively high amounts of copper. These latter bronzes have a high electrical and thermal conductivity, making resistance welding difficult. Two of the popular types of bronzes are the phosphor bronze and the silicon type of bronze (the silicon type being the easiest to weld of the two) and both are relatively as easy to weld as low carbon steel.

Sheet can readily be spot, projection, seam, flash and upset welded, while rod and wire can be cross-wire projection welded or flash-butt and upset-butt welded. The whole range of processes may be employed for the welding of many types of bronze tubing. The same welding conditions as required for brass also apply to bronze.

MAGNESIUM. Practically the same types of welding machines, precise controls, and working techniques are required in the welding of magnesium as for aluminum. Magnesium also has a very high electrical and thermal conductivity, a relatively low melting point, and a very sensitive plastic range. It is particularly sensitive to over-burning.

ZINC. Zinc and zinc-base die cast materials have been welded satisfactorily by spot, projection, seam and upset-butt welding. Although the welds are thoroughly satisfactory, the strength is not equal to the parent metal due to coarseness of the grain structure in the

weld nugget. Zinc and zinc-base die cast materials should be cleaned, and all grease, oil and oxides removed before welding.

Zinc requires a low electrode force to avoid extreme indentation or complete penetration. Lower currents and a longer weld time are used than for steel. Due to the extreme sensitivity of zinc, precise synchronous controls are necessary, and the problem of pick-up on the electrodes is at present a factor that slows up production. This pick-up must be frequently removed, or electrodes will stick; for that reason, electrodes should be water cooled to the lowest possible temperature. Molybdenum or Elkonite tips may help.

LEAD. Techniques and procedures used in the successful spot, projection, seam and upset-butt welding of lead are similar to those used in the welding of zinc and zinc-base die casting materials. Here again, because of the low melting point and the unusual softness of the metal at normal temperature, the tip pressure and welding current must remain very low. In the welding of both zinc and lead, the welding machine should have a low inertia moving tip and minimum-friction type welding head mechanism.

COPPER. Copper has been successfully upset-butt or flash-butt welded by a special technique involving a short flashing period, (to provide a good clean surface) followed by a regular upset-butt weld. Copper chain, rods, bars, and wire ranging from 0.010 to 1.0 in. diameter, have been successfully upset-butt welded in this manner. Many copper mills use the upset-butt welding process to join the ends of coils and wire to provide continuous coiling during manufacturing and coating operations.

Because copper has a high electrical and thermal conductivity and no plastic range before its melting point, it has seldom been successfully spot, projection or seam welded. Welding electrodes of molybdenum or Elkonite may be used to increase the heating rate and reduce the thermal loss into the tips and at the same time to minimize pick-up.

BERYLLIUM COPPER. Beryllium copper, in contrast to regular copper, is easily weldable by all resistance welding processes. Special controls and welding machines like those used in the welding of brass and the bronzes are required.

CAST IRON. Cast iron has not been resistance welded on a practical production basis. Only by the performance of some very critical operations and a pre-heating of the cast iron to between 1,200 F and 1,400 F have spot welds been made on untreated cast iron as thick as $\frac{1}{4}$ in. Ordinarily, if it were spot welded, it would crack at the welding area because of carbon solution and quenching. However, when annealed to give low combined carbon, machined, and then surface-treated in molten alkalies to remove free carbon, it may be spot welded to sheet steel at such machined and treated surfaces.

COATED METALS. Many coated metals such as aluminum coated steel, galvanized iron, tinplate, terneplate, cadmium plated steel and others can be joined by resistance welding methods, although the coatings of the metals cause higher contact resistance and necessitate much more frequent cleaning of the welding tips to remove the "pick-up" of oxides.

Care also must be taken to avoid the following: alloying of the coating to the base metal, which may cause brittleness in the weld area; burning of the surface and removing of the plating at the weld area, with the resulting possibility of corrosion, particularly with such electroplates as hard chromium and cadmium; and insufficient pressure at the weld area, with the result that the coatings of the two metals are joined in a "stick" weld or in a localized soldered joint.

NICKEL. Nickel has a slightly lower resistance and melting point than steel, and requires a slightly higher current density and electrode pressure. While it and its more common alloys (such as Inconel, Monel, and nickel silver) can be easily welded by all of the resistance welding methods, precise synchronous welding controls should be used in conjunction with anti-friction, low inertia types of rams in the welding machines.

ALNICO. Alnico is not satisfactory for resistance welding due to the resultant crystaline structure and poor bonding in the surrounding weld area.

TANTALUM. Special techniques are required to satisfactorily weld tantalum due to the absorption of various gases into the weld—unless the weld area is properly protected. Such techniques include immersion in water or carbon tetrachloride during the welding operation.

TUNGSTEN AND MOLYBDENUM. A true resistance weld of tungsten is, for the present, not practical. The high melting point and the high oxidation rate of the metal at welding temperatures makes resistance welding impractical. The high temperature required also result in re-crystalization and brittleness. Nickel can be welded to tungsten only "after a fashion": when the nickel becomes melted at the tungsten surface, it adheres similarly to a soldered bond.

Molybdenum can be resistance welded by spot, projection, seam and upset-butt welding. A short welding time is required at a high power level. Due to grain growth in the weld nugget, the welds may be slightly brittle and of low strength unless proper controls are employed.

PRECIOUS METALS. Gold and many of the gold alloys can be spot, projection, seam and upset-butt welded, but the techniques and special skills of achieving such welds are not generally used outside the jewelry manufacturing industry.

Silver has been extensively projection welded to base metals of copper, phosphor bronze, beryllium copper, and brass in the manufacture of electrical contacts; a fine line is drawn between the resistance welding processes and joining by silver soldering. Silver has a low electrical resistance and therefore, requires relatively larger amounts of welding current to raise the temperature to the welding point. Many aids are employed to effect this rise, such as electrodes faced with molybdenum or tungsten. These tips have high electrical resistance and poor heat conductivity, and consequently add extra heat to the silver by conduction.

Platinum has been extensively welded to many small parts in specific instances such as the manufacture of electronic tubes, platinum-tipped fountain pen points, and jewelry. Most spot, projections, seam or upset-butt welders used for these purposes are of bench size. Platinum and its alloys containing iridium, osmium, palladium and other rare metals are nearly all equally easy to weld.

ANTIMONY, BERYLLIUM, BISMUTH, CADMIUM, TELLURIUM AND TIN. Each of these metals has been spot, projection, seam and upset-butt welded but only with special equipment and in experimental laboratories. To date very limited use has been found for such welding.

DISSIMILAR METALS. Charts on the weldability of various metals disclose that many metals are readily weldable to similar metals but are not as easily weldable to metals of dissimilar characteristics.

The spot welding of dissimilar metals of greatly different electrical resistance characteristics or welding temperatures is accomplished by the use of dissimilar tip or electrode materials; electrode materials are avail-

Table II — Recommended Electrode Materials for Spot Welding Similar and Dissimilar Metals

LEGEND

WELDABILITY
A — Excellent
B — Good

SPECIAL INFORMATION
1 — Special conditions required.
2 — Good practice recommends cleaning before welding
3 — If plating is heavy, weld strength is questionable

BLOCK INTERPRETATION

Weldability	Electrode Against
Electrode Against	Special Information

ELECTRODES
R.W.M.A. Specifications

I — Group A Class 1
II — Group A Class 2
III — Group A Class 3

Note: Electrode materials in circles are second choice-example

TO WELD SIMILAR METALS — READ BLOCK UNDER METAL TO BE WELDED

Tin Plate Steel		Terne Plate Steel		Galvanized Iron Zinc Plate		Cadmium Plate Steel		Chrome Plate Steel		Stainless Steel 18-8 Type		Scaly H.R. Steel		C.R. Steel H.R. Steel Clean	
B	I	A	I	A	I (II)	B	I	A	III	A	III (II)	B	I (II)	A	III
I	3	I	3	I (II)	3	I	3	II	3	III (II)		I (II)	2	II	

Aluminum		Aluminum Alloys Dura-luminum		Cupro Nickel		Nickel Silver		Nickel		Nickel Alloys Monel Nichome (High Res.)		Brass Yellow 25%-40% Zinc		Phosphor Bronz Grade A, C & D		Silicon Bronze Everdur Olympic Duronze Herculoy	
B	I (II)	B	I (II)	A	III	B	II	A	II	A	II	B	II	B	II	B	II
I (II)	2	I	II 2	II		II		II		II		II		II		II	

TO WELD DISSIMILAR METALS — READ BLOCK UNDER METAL TO BE WELDED

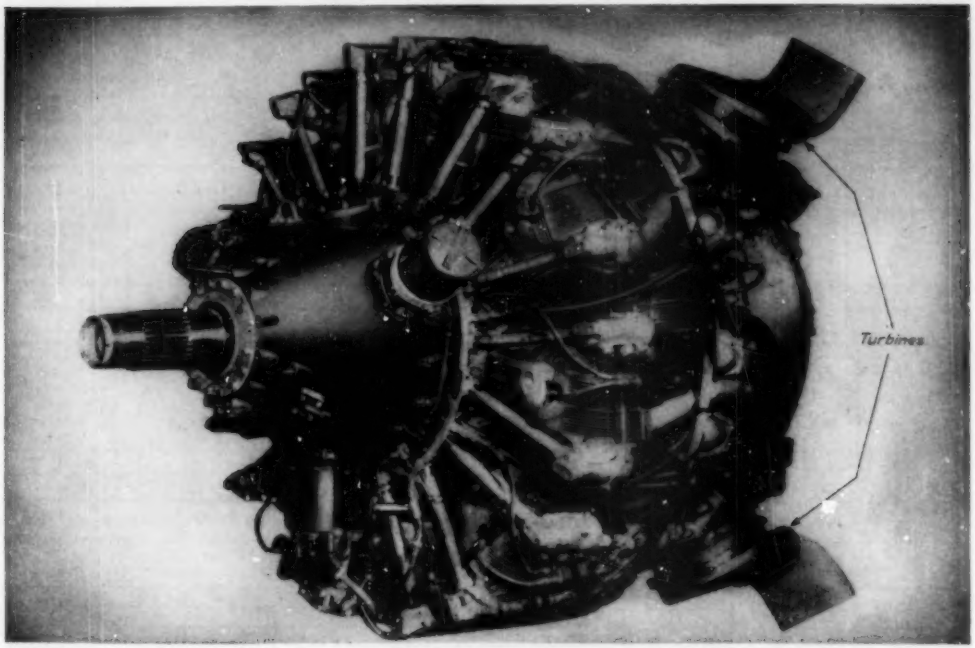
Ferrous Alloys	Stainless Steel 18-8 Type		Chrome Plate Steel		Cadmium Plate Steel		Galvanized Iron		Terne Plate Steel		Tin Plate Steel	
Cold Rolled Steel Hot Rolled Steel, Clean	A	II (B)	A	II	B	II	B	I	A	I (II)	B	I
	II		II	3	II	3	II	3	II	3	II	3
Tin Plate Steel	B	II (B)	B	II	B	I (II)	B	I	B	I (II)		
	I		I	3	I	3	I	3	I	3		
Terne Plate Steel	B	II	B	II	B	I (II)	B	I				
	I	3	I	3	I	3	I	3				
Galvanized Iron Zinc Plate	B	II	B	II	B	I						
	I	3	I	3	I	3						
Cadmium Plate Steel	B	II	B	II								
	I	3	I	3								
Chrome Plate Steel	A	III (II)										
	II	3										

Nonferrous Alloys	Nickel Alloys		Nickel		Phosphor Bronze		Silicon Bronze		Yellow Brass		Nickel Silver	
Cupro Nickel	B	II	B	II	B	II	B	II	B	II	B	II
	II		II		II		II		II		II	
Silicon Bronze Everdur Olympic Duronze-Herculoy	B	II	B	II	B	II	B	II	B	II		
	II		II		II		II		II			
Nickel Silver	B	II	B	II	B	II	B	II				
	II		II		II		II					
Nickel Alloys	A	II	B	II								
	II		II									
Stainless Steel 18-8-Type	B	II	B	II								
	III (II)		II (B)									

Nonferrous Alloys	Aluminum	
Aluminum Alloys Duraluminum	B	I (II)
	I (II)	2

able in varying degrees of resistances from pure copper to tungsten. Another method of achieving heat balance in dissimilar metals is by the application of different sizes of contacting tips, electrodes or dies. The smallest contacting area is used against the material having the lowest resistance or the highest melting temperature, and the largest contacting electrode surface is used on the metal having the highest resistance, or the lowest melting temperature.

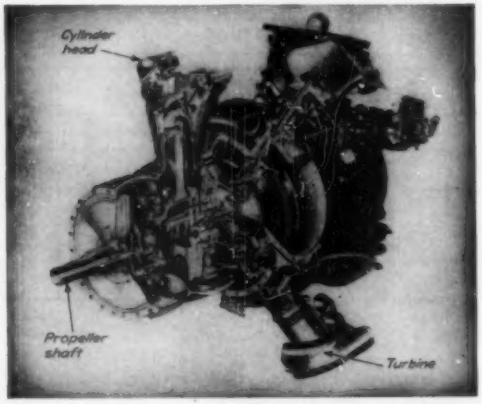
Tables I and II show generally weldable combinations of metals and the type of electrode materials that should be used with the various combinations. These tables should be studied before the use of certain metals or combinations of metals are specified in design.



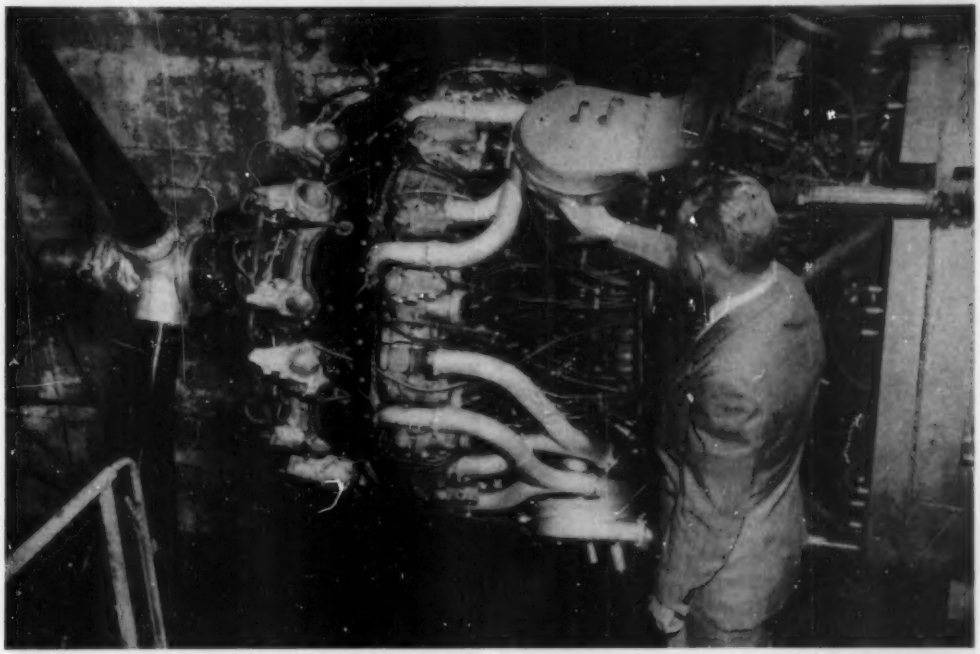
THREE GAS TURBINES added to this 18-cylinder airplane engine have increased its horsepower rating by 20 percent. The turbines recover power from the engine's exhaust gases and feed it directly back to the propeller shaft. Wright engineers used their standard engine in this project without affecting its basic design.

Gas Turbine Compounding Adds 550 Hp to Engine

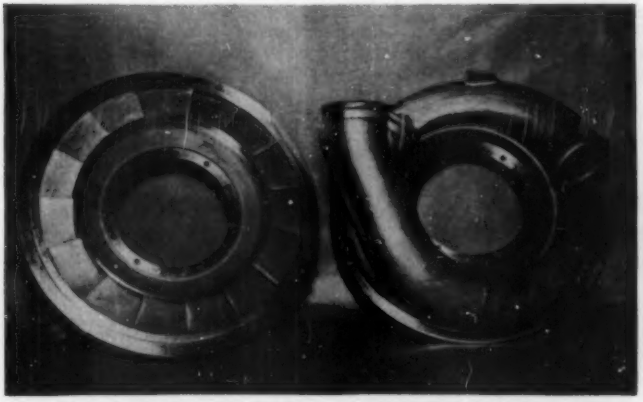
Gas turbine and reciprocating engine design are combined in the new Turbo-Cyclone compound engine. The basic structure is a standard 2,700 hp radial engine upon which are mounted three exhaust-driven gas turbines. Without affecting fuel consumption, use of the turbines increase the engine's available hp to 3,250. The addition of the turbines was accomplished without increasing overall diameter while the engine's weight factor was reduced to .965 lb per hp. The Wright-Aeronautical Corporation of Wood-Ridge, N. J. manufacturers the Turbo-Cyclone 18 engine.



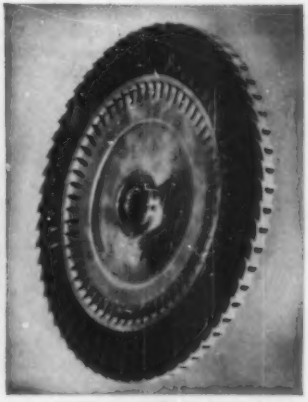
ENERGY recovered by the turbines is fed directly back to the propeller shaft. The impulse turbines use only the kinetic energy in the exhaust. There is still the possibility of recovering a greater percentage of the exhaust energy by the addition of pressure turbines and jet stacks.



EXHAUST GASES from a bank of six cylinders are fed into each of the three turbines. The turbines are of the impulse or velocity type. Impulse turbines were chosen because they exert virtually no back pressure on the engine cylinders. This would not be true of the pressure or reaction type turbine which offers considerable resistance.



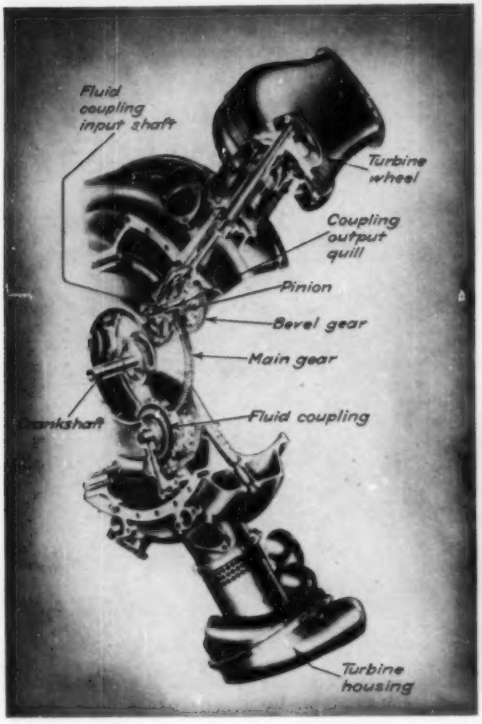
TOP AND BOTTOM VIEWS of the turbine nozzle assembly show arrangement of inlet pipes and stator vanes. Nozzle is investment casting of stainless steel. The exhaust gas enters the turbine rotor at a velocity determined by cylinder pressure and temperature at the instant of exhaust valve opening. The stator blading determines the angle of entry.



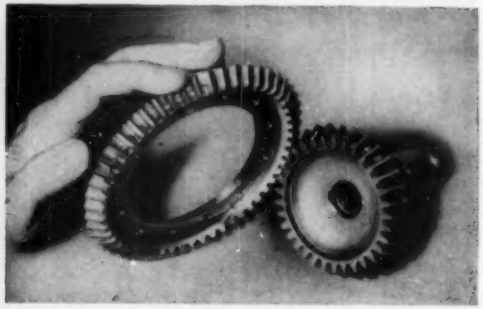
CAST STELLITE blades are welded to the turbine wheel hub, which is of nickel alloy steel. Nozzles direct the exhaust gas against the turbine blades.

(*continued on next page*)

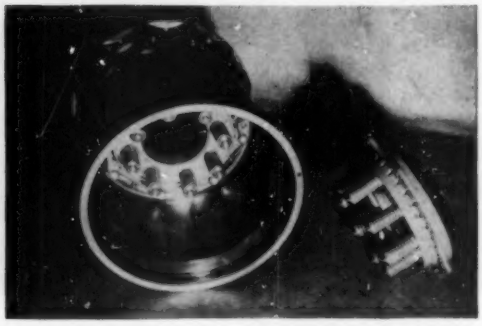
Gas Turbine Compounding Adds 550 Hp to Engine (continued)



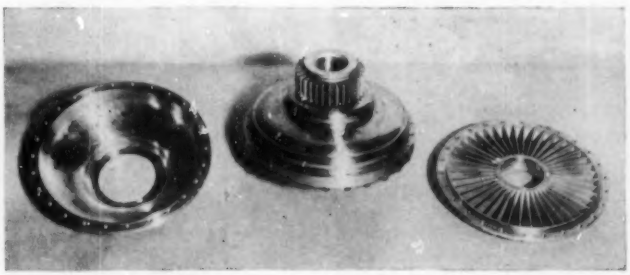
TURBINE WHEEL TORQUE is transmitted from the turbine shaft through a quill or coupling shaft into a bevel shaft gear. The bearings for this shaft gear are mounted in the engine housing. A mating bevel gear drives the impeller shaft of the fluid coupling. The output shaft of the fluid coupling is a quill and carries the pinion that meshes with the main drive gear on the engine crankshaft. All three turbines feed into the same gear.



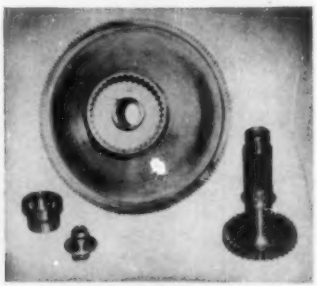
ZEROL BEVEL GEARS connect turbine wheel shaft to input shaft of the fluid coupling. These gears are designed for high speed operation. Shaft rides on silver bearings.



LATERAL VIBRATION DAMPER helps anchor the turbine shaft support assembly within the turbine housing. Above picture shows damper before and after assembly. The damper consists of flat friction disks loaded by 8 springs. The function of this unit is to absorb the forces that occur at resonant frequency points in engine operation. These forces are set up by engine vibrations and by intermittent exhaust gas pulses acting on the turbine wheel.

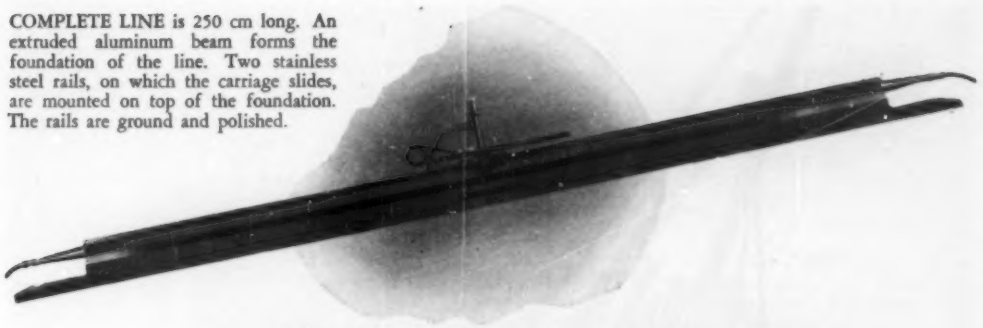


FLUID COUPLING is installed between turbine wheel and propeller shaft. The coupling aids the drive gears in absorbing turbine torsional vibrations and also effectively isolates these vibrations from the propeller shaft. The coupling operates at essentially constant slip, 1 or 2 percent. The turbine is run at a fixed ratio of engine speed. One feature of the coupling design is that both input and output shafts project from the same side.



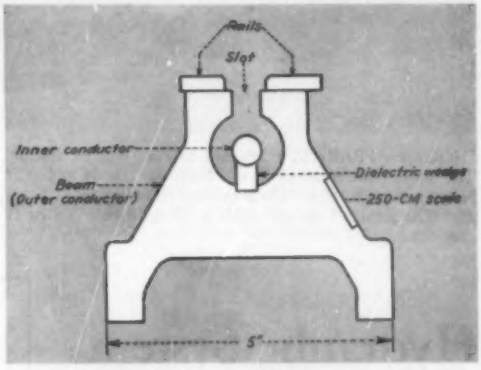
RECOVERED POWER is returned to propeller crankshaft through this drive gear and splined coupling. Small parts are spacers. The output gears of the three fluid couplings mesh with the large drive gear.

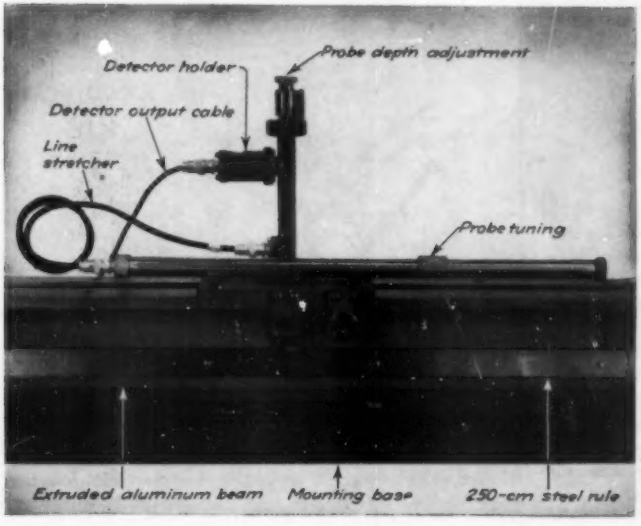
COMPLETE LINE is 250 cm long. An extruded aluminum beam forms the foundation of the line. Two stainless steel rails, on which the carriage slides, are mounted on top of the foundation. The rails are ground and polished.



Aluminum, Stainless, Plastics Combined in Precision Device

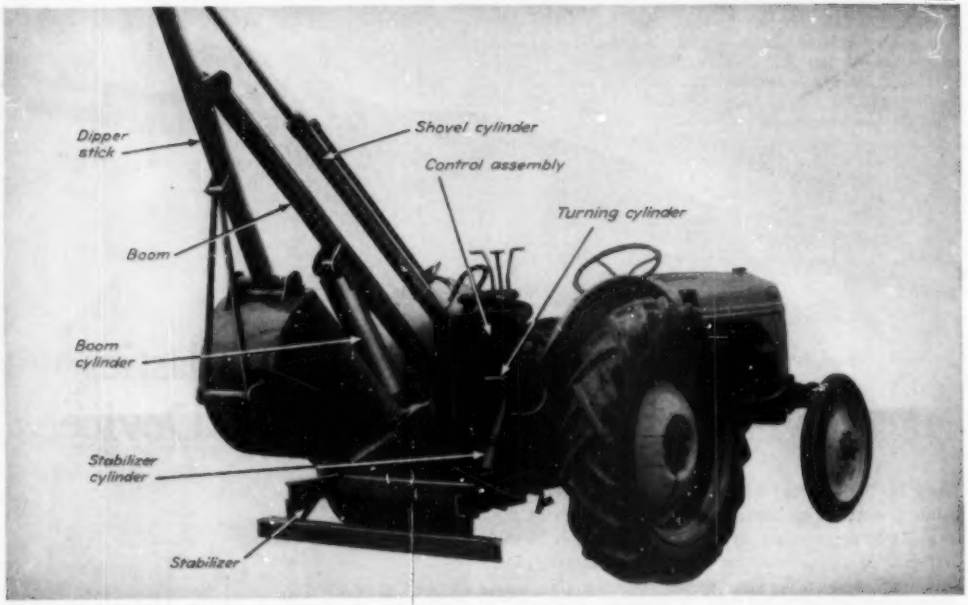
The FTL–30A Slotted Line is a device for measuring standing-wave ratio, impedance and wavelength in the 60 to 2,000 megacycle range. Its application is in the development and adjustment of antennas, transmission lines and associated equipment. Because this is a precision apparatus, engineers of the Federal Telecommunication Laboratories in Nutley, N. J., selected their materials carefully. Weather resistance and accuracy over wide temperature variations were requirements in this design. The nature of the testing work involved requires the slotted line instrument to be used in out door locations. Accordingly, any tendency of the component materials to rust or warp would be undesirable. Current carrying parts are aluminum rather than copper.





SLOTTED LINE is connected between radio-frequency generator and a load (the device being examined). From the variation of voltage along the inner conductor, the impedance of the load may be computed. The carriage that slides on the rails contains a probe. This probe picks up a small voltage that is proportional to the voltage on the inner conductor at the location of the probe.

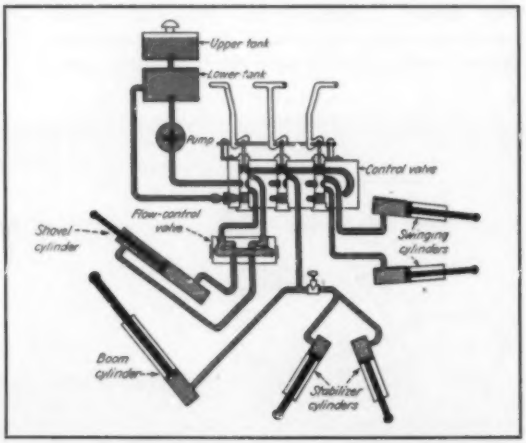
ALUMINUM INNER CONDUCTOR is mounted within the top channel of the beam. A polystyrene wedge accurately spaces the rod from the beam. The assembly is secured by fiberglass screws. Polystyrene is used for the wedge because of its good machining qualities and since its coefficient of expansion is much closer to that of aluminum than those of other low-loss insulating materials.



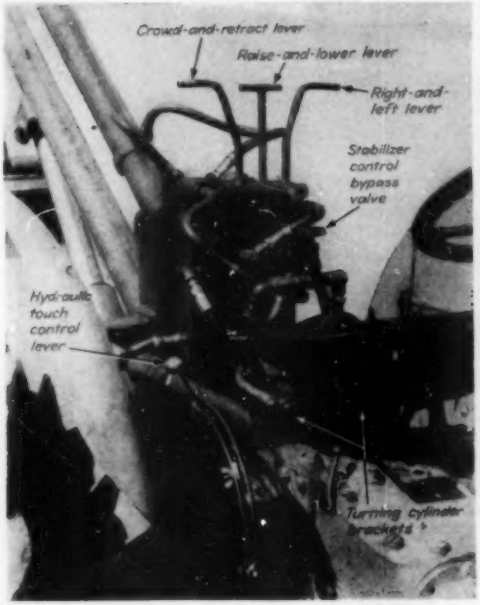
DIGGER APPARATUS attaches to rear end of tractor. The shovel can reach 11 ft out from the tractor and 6 ft below ground surface. The boom can be swung in a 93 deg arc. The standard shovel width is 18 in. with a 3.5 cu ft capacity. The hydraulic system that powers the apparatus is designed to withstand 10,000 psi. However, operating pressure is only 1,500 psi, which is the relief valve setting. Operator manipulates the digger by means of valve levers.

Hydraulic System Simplifies Power Shovel

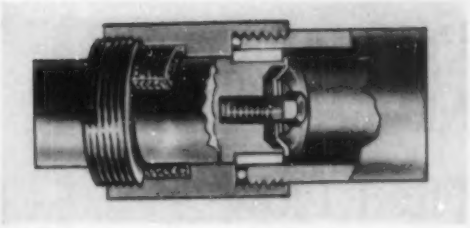
The Sherman Power Digger attachment converts a farm-size tractor into a heavy-duty excavating machine. Its designers selected a hydraulic drive system to avoid complicated mechanisms. No rack gears, cables, reels, clutches or chains are used. The hydraulic system also means simple controls and facilitates rapid installation and dismantling. The 1,000 lb apparatus can be installed in about 45 min. A take-off from the tractor transmission powers the shovel which can handle rocks weighing as much as one ton. The Wain-Roy Corporation manufactures the apparatus for Sherman Products, Inc. of Royal Oak, Michigan.



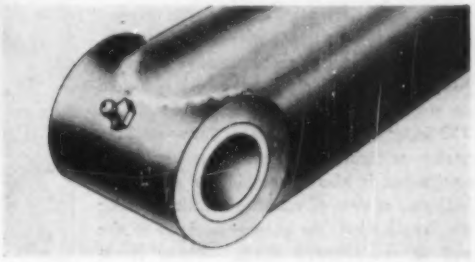
ALL OPERATIONS are hydraulically powered and controlled. Upper and lower tanks provide an oil reservoir to replace oil lost from the system by seepage. The continuously acting pump forces oil to the control valves which route it to the operating cylinders. Excess oil is ported back to the reservoir. A flow control valve automatically opens to vent one side of the double-acting shovel cylinder when pressure is applied to the other side. Diagram above illustrates the hydraulic circuits and control valves.



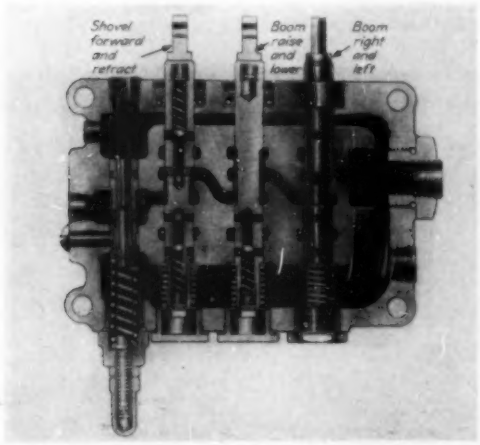
DIGGING THRUST is taken by a stabilizer bar. This actually is a hydraulic jack, which lifts the rear wheels during digging operations. The operator admits hydraulic pressure to the stabilizer cylinders through a valve.



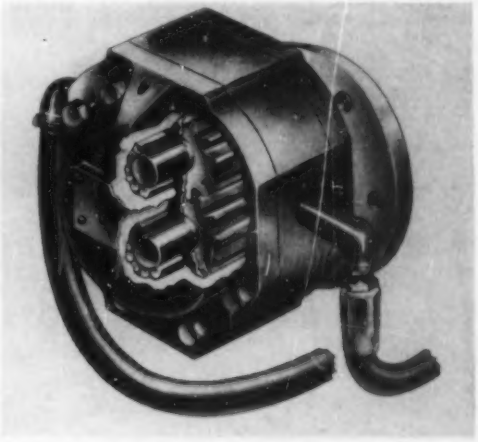
CYLINDERS are of simple design with Chevron type packing and adjustable packing glands. The shovel cylinder is double-acting. All others are of the single-acting type. System capacity is about 5 gallons.



ALL BEARINGS in the boom, dipper stick and swinging assembly support frame are replaceable bronze bushings. Pressure gun lubrication fittings are provided at all wear points. Apparatus is welded construction throughout.



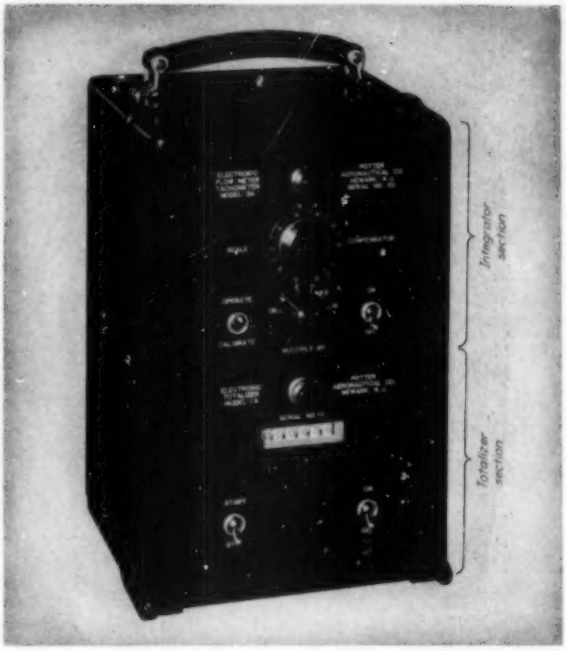
SLIDING VALVES control all digging operations. The spring-loaded valves return to the off position when released. This is a safety feature which prevents digger from functioning should operator lose control. Oil pressure is delivered to valves from left to right. When a valve is open, the valve or valves to the right of it will be isolated from the pump. Thus, pump does not supply power for more than one operation at a time.



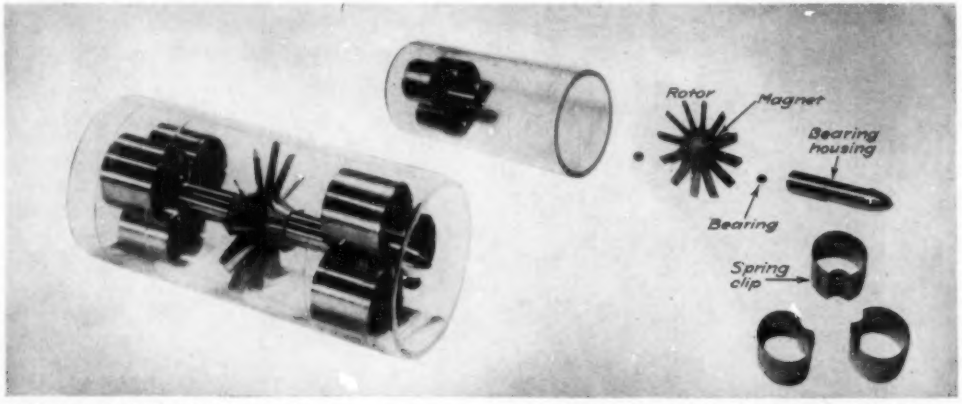
GEAR PUMP supplies the hydraulic system of the digger attachment. Its capacity is 6 gpm. The power take-off shaft of the tractor drives the pump through a 2½:1 step-up transmission. Tractor throttle is set to give the pump an operating speed of about 1350 rpm. System is designed to use standard type of automobile engine oil in place of special hydraulic oils. The latter are more costly than car oils and not so widely available.

Permanent Magnet Measures Fluid Flow

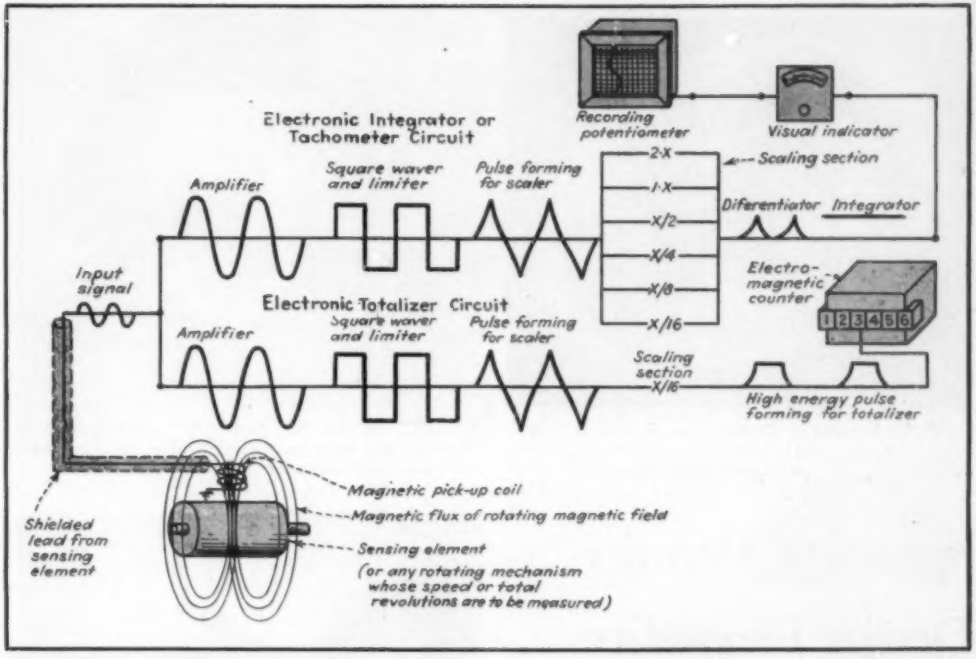
The Potter Flow Meter continuously measures and records both the rate and volume of fluid flow. Feature of the apparatus is a small turbine rotor containing a permanent magnet. When the rotor is installed in a fluid passage, it sets up a rotating magnetic field. The field generates an electrical signal which is picked up and interpreted by electronic equipment. The latter consists of two sections—an integrator or tachometer and a totalizer. The equipment is also adaptable for use as an indicator of rpm of rotating machinery. For that application, the magnet is fixed to the end of the rotating shaft. Potter Aeronautical Company is in Newark, New Jersey. Electronic integrator and totalizer are contained in a compact, portable case. The two components are identical in size and have individual power supplies. This makes it possible to use same case for either two integrators, two totalizers or the combination.



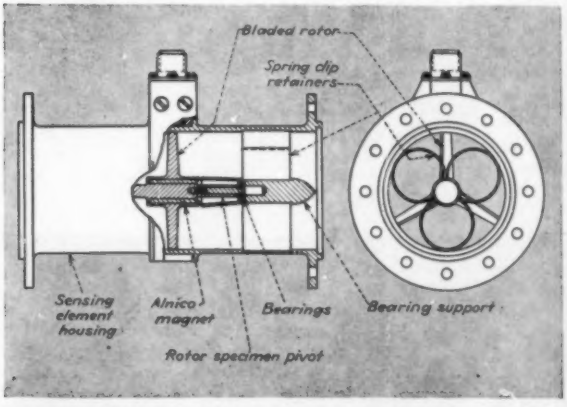
WHEN THE COMBINATION UNIT shown above is coupled with a flow sensing-element it is possible to obtain fluid flow rate from an attached visual indicator or recording potentiometer, and total flow values upon the panel electro-magnetic counter. The calibration of the electronic integrator circuit can be checked by built-in electrically actuated turning fork.



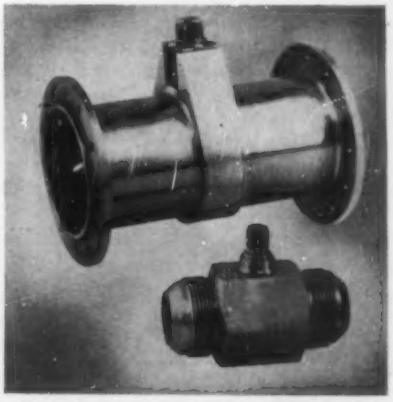
SENSING ELEMENT is inserted in the duct that contains the fluid being measured. A small permanent magnet is fixed within the rotor hub. In operation, the magnet sets up a rotating field, which passes through the non-magnetic housing. The field generates a minute electrical current in an externally placed pick-up coil. The frequency of this current is directly proportional to the speed of the rotor blades and is the value used by the electronic integrating circuit. Inertia, bearing friction and the generated electrical energy are the only factors which absorb power from the rotor. The aim of the designers was to keep these values small so that element speed would respond instantly to flow changes. The sensing element offers the least possible resistance to fluid flow.



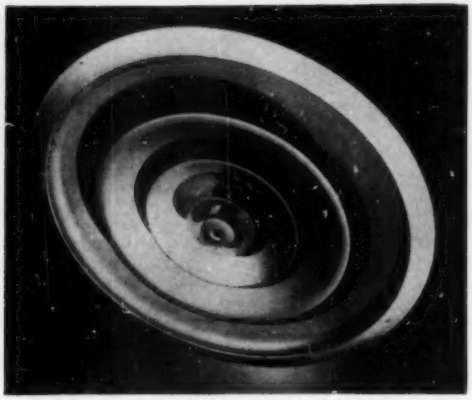
PROGRESS OF SIGNAL from the pick-up coil through the electronic units is shown above. Upper section measures rate of flow. Lower section records total flow. The signal is amplified and converted to a square wave. The pulse former then shapes the square wave for use by the scaling section. In the tachometer circuit, the scaling section has six possible channels, any one of which can be selected by means of a panel switch. The scaling section determines the range of the instrument. The values indicated above are the multiplication factors of the various channels. The signal becomes direct current for tachometer operation or pulsating current for counter use.



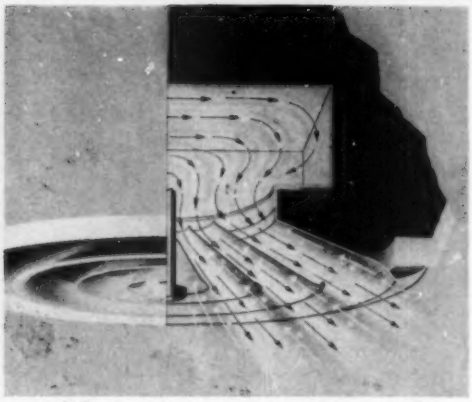
CYLINDRICAL SPRING CLIPS support the rotor inside the sensing element housing. These fit into a slight channel in the bearing housing and in a corresponding channel on the inside diameter of the element housing. Fluid thrust is taken up by the spring clips in shear against these channels. This construction provides a flexible bearing mounting, which can transmit large thrust forces. Yet, assembly and removal of the sensing element mechanism is simple.



FLUID FLOW SENSING ELEMENTS can be manufactured to suit any pipe or duct system. Above is shown two types of element housings. The only requirement is that the housing material be of a non-magnetic nature. This is so that magnetic flux will pass freely through the housing wall.



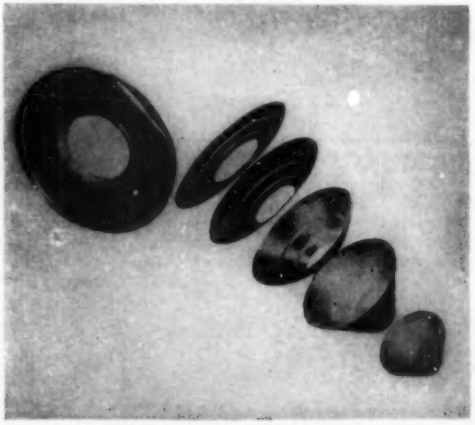
DIFFUSERS spread air through room in accordance with a definite pattern. Each design has a characteristic pattern, determined by size, spacing and angle of the cones.



PASSAGE OF AIR through diffuser siphons a series of counter-currents back into the cones. Thus, the conditioned air is mixed with room air before leaving diffuser.

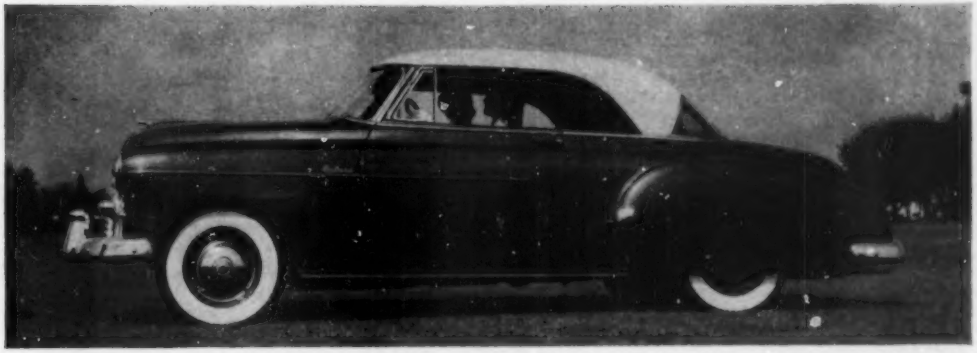
Spinning Permits Design Flexibility

Besides controlling the rate and direction of air flow, the Anemostat diffuser premixes conditioned air with room air. Premixing modulates the temperature of the incoming air so it cannot be felt as a hot or cold draft. Because of design variables, there are several hundred different models of diffuser possible, each suited to a specific type of installation. If the designers chose to standardize on a few models, these could be produced in volume by stamping. Instead, metal spinning was the production process specified. Since no expensive dies are required, every possible design of diffuser can be produced economically in small quantities. The Anemostat Corporation of America is in Hartford.



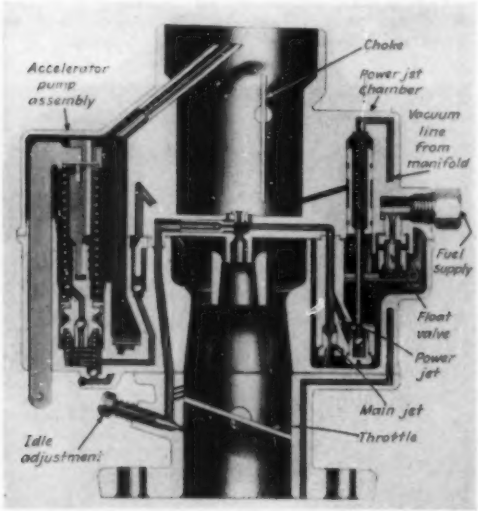
IN THE LARGER MODELS, diffuser cones range up to 8 ft in diameter. Regardless of size, cones are formed by spinning over wooden dies. Aluminum and stainless steel are metals most commonly used.

BALL AND SOCKET COUPLING secure the spacing rods inserted between adjacent cones. This type coupling makes for easy assembly since it allows for slight variations in alignment. Since it can accommodate any cone angle, this same fitting can be used in all models of these air-conditioning diffusers.

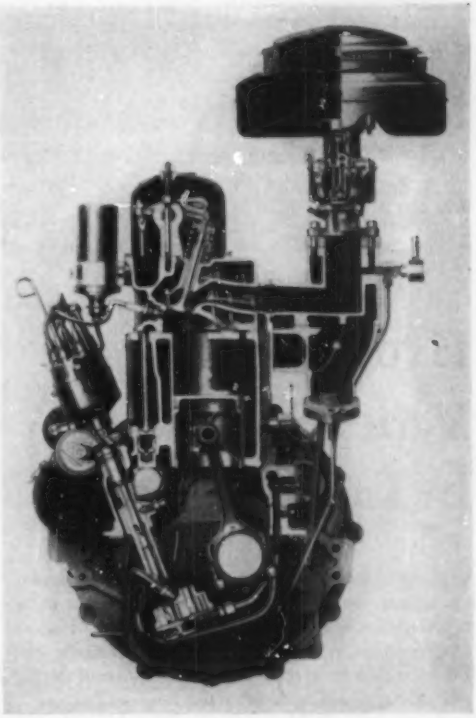


Larger Engine Drives Chevrolet's Powerglide

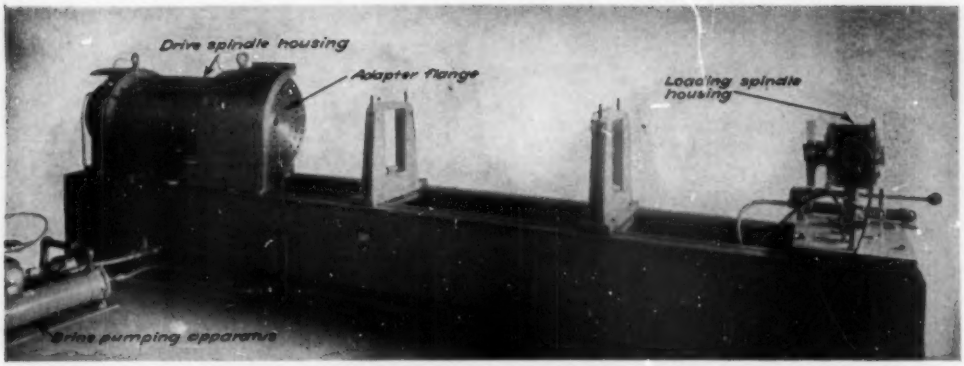
Chevrolet's new torque converter automatic transmission, "Powerglide", is the feature of the 1950 line. Basic design is similar to Buick's "Dynaflow". To keep cost low, stampings are used in place of castings wherever possible. A bigger engine, using hydraulic valve lifters, is offered with the automatic transmission. Pictured above is the new hardtop convertible.

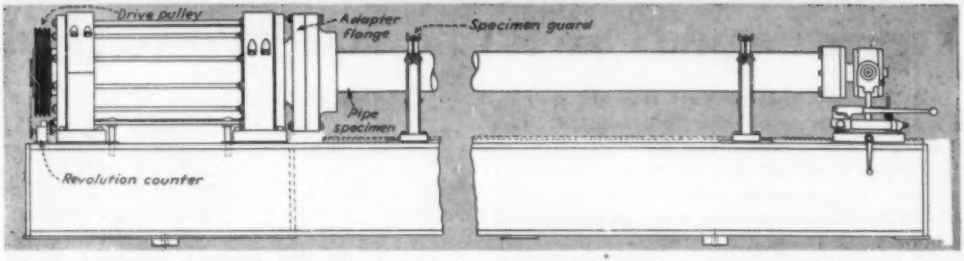


CARBURETOR HAS VACUUM OPERATED AUXILIARY JET, called the power-jet. This automatically enriches the mixture as needed during acceleration. An increase in manifold pressure actuates the spring loaded power-jet valve. When this valve is open, it acts in parallel with the main jet, providing an additional flow of gas from the fuel bowl to the Venturi tube. The concentric fuel bowl and double float assembly permits more constant fuel level on grades and curves at all speeds.



ADDED POWER NEEDED FOR CONVERTER OPERATION is supplied by new 105 hp engine. This output is developed at 3,600 rpm. Displacement is 235.5 cu. in. with bore and stroke of $3\frac{9}{16}$ by $3\frac{1}{8}$ in. The engine used with the standard transmission develops 92 hp at 3,400 rpm. Displacement is 216.5 cu in. with bore and stroke of $3\frac{1}{2}$ by $3\frac{3}{8}$ in. The bigger engine is equipped with hydraulic valve lifters. In torque converter cars, rear axle ratio is reduced from 4.11 to 3.55 to lower engine speed.

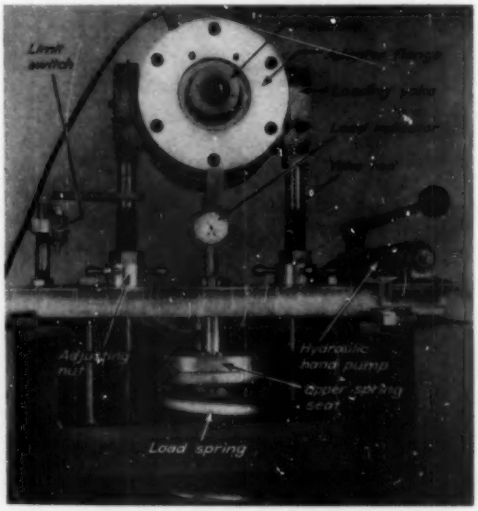




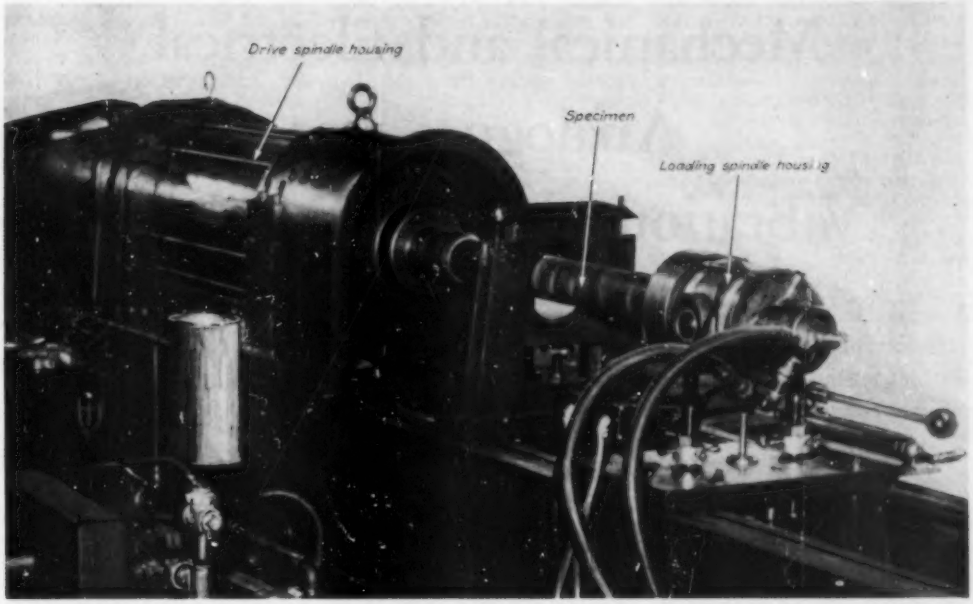
THIS MACHINE FATIGUE TESTS sections of oil-well drill pipe measuring up to 8¾ in. in diameter and 120 in. long. Spherical roller bearings support the main drive spindle. Because of the heavy, unbalanced loads impressed on these bearings, the designers had to take special precautions to insure long bearing life. A cylindrical housing shields the bearings from dust. In addition, they are cooled and lubricated by a forced-feed oil system.

Hydraulic Cylinder Varies Spring Load In Fatigue Tester

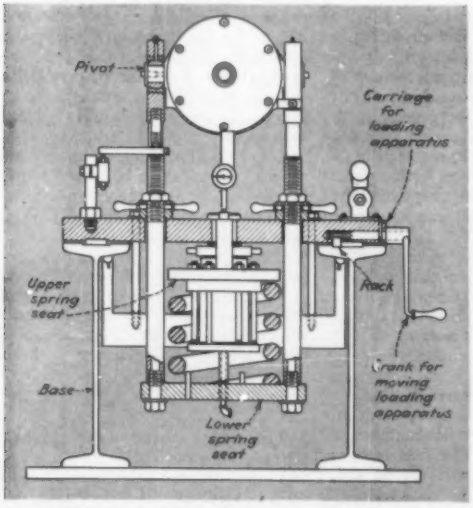
Seamless steel pipe for use in oil well drilling operations can be subjected to simulated service conditions in this new corrosion-fatigue tester. The horizontally-mounted pipe is supported at one end in cantilever fashion while a force is exerted on the other end. Rotation of the pipe sets up the reversing stresses that lead to fatigue. A 25 hp motor in the base of the machine drives the pipe under test. Designers of this machine selected a variable speed motor to provide low rotating speeds for corrosion-fatigue testing and higher speeds for air-fatigue testing. Top speed is 1,000 rpm. Peak load is 1,200,000 in.-lb. National Tube Company, a United States Steel Corp., subsidiary, Pittsburgh, and the Sonntag Scientific Corp. of Greenwich, Conn., collaborated in this design.



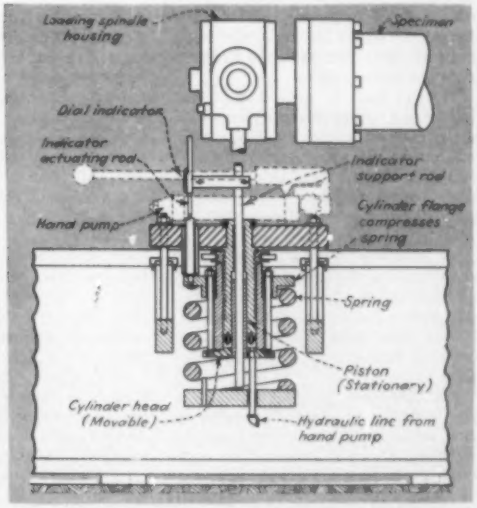
LOADING END of machine has a calibrated coil spring which exerts a vertical downward force on the threaded rods that hold the loading yoke. Load on the specimen, is regulated by varying the position of the upper spring seat. Adjusting nuts limit the drop of the yoke.



PIPE SPECIMEN is mounted between the flanges of the drive spindle and the loading spindle. As the pipe rotates, it is subject to continuous stress reversals. Both drive and loading spindles operate on roller bearings. Brine, simulating the corrosive muck encountered in oil-well operations, is pumped through the specimen during the entire test. The circulating brine flows into and out of the specimen through the hollow center and packing glands of the load spindle. Bearings of the machine are cooled and lubricated by a forced feed oil system.



HYDRAULIC HAND PUMP and cylinder compresses the loading spring to establish the initial load desired. Then, the holding nut keeps the spring in the compressed position. The lower spring seat and the threaded yoke rods transmit the load to the loading spindle housing.



TO ALLOW for bending of the specimen, this housing is connected to the yoke rods by pivots. A dial indicator measures spring deflection, from which the load in pounds can be determined. A rod running through the center of the piston supports the indicator

Mechanical and Electrical Analogues For Vibration Isolation Problems

Two mechanical and two electrical analogues are developed to represent the coupled vibrations of machine on resilient mounts. Techniques and theory for measuring the frequencies and mode shapes of machine by simple experimental means are discussed.

WALTER W. SOROKA
Engineering Design Division, University of California

MOUNTS FOR ISOLATING MACHINE VIBRATIONS usually have both lateral and axial flexibility. Their locations are generally such that translation of the machine induces rotation as well, and vice versa. Thus, coupling exists between translational and rotational motions. In the usual treatment of this problem, all mounts are considered identical and are assumed to be symmetrically placed with respect to the center of gravity of the machine, and an analysis made following the standard procedure for a two degree of freedom oscillatory system.

A rigid body in space may be subject to three different translations (one along each coordinate axis) and three rotations (one about each coordinate axis), so that six degrees of freedom and, correspondingly, six natural coupled frequencies are possible. The coupling between some of these motions, however, is weak and is usually neglected for the sake of obtaining a practical solution to the problem. The analytical treatment is, therefore, broken down into separate studies of one and two degree of freedom systems.

For simplicity, damping in the resilient mounts is also usually neglected. In a single degree of freedom analysis damping is readily accounted for without appreciable analytical complication. In two or more degrees of freedom, the introduction of damping results in considerable complication of the analytical treatment.

Certain mechanical and electrical oscillatory systems are exact analogues of the machine on its isolating base and can be used as a means for visualizing, analyzing and experimentally studying the vibration isolated machines over a wide range of variable parameters. In some of these analogues damping is readily introduced in controlled amounts without affecting the ease with which experimental results can be attained.

Machine on Resilient Mounts

In the common arrangement of a machine on resilient mounts shown in Fig. 1, an impressed force or an impressed moment will produce coupled translational and rotational motions of the machine mass. For generality, an impressed force F_1 is shown as acting at a distance e from the center of gravity. This force produces both a force at the center of gravity of the machine and a moment about the center of gravity.

The force might be further generalized by directing it so that it has a vertical component. Coupling, however, does not exist between vertical motion and the other motions, so that the system under the influence of the vertical force component may be treated as a single degree of freedom system executing vertical vibrations independently of the horizontal and rotational motions. The latter case is easily handled and will not be considered further.

It is desirable to present the problem in its most general form. Hence, the mounts are shown with damping represented by a small dashpot across each spring. The spring stiffnesses in the horizontal and vertical directions are different, as are the damping coefficients. The machine has a mass m_1, and a radius of gyration r. Since the usual amounts of damping present in such systems have only a minor effect on the natural frequencies of the machine, whereas they might have considerable influence on the amplitudes of the machine under the action of the impressed forces, two sets of equations will be written to describe the system.

The first set of equations will be that governing the free vibrations of the system and will exclude damping; this set will be used to study the natural frequencies of the coupled system. The second set will be that expressing the response of the system to impressed forces and will, therefore, include damping.

Referring to Fig. 1, k_x and k are the stiffnesses, lb/in., of the horizontal and vertical springs respectively, b is the perpendicular distance from the c.g. to the line of action (usually the base of the machine) of the horizontal springs, and b is the perpendicular distance from the c.g. to the lines of action of the symmetrically placed vertical springs.

Consider the center of gravity of the mass m_1 to have a horizontal translational acceleration of magnitude $\ddot{x}_1$ to the right, and the mass to have a clockwise angular acceleration about its center of gravity of magnitude $\ddot{\theta}$. At this instant of time the translational and rotational displacements of the c.g. will be x_1 and θ to the right and clockwise respectively. In this position the right horizontal spring will be compressed an amount

$$x_1 - b\,\theta$$

and the left horizontal spring stretched the same amount. The two springs acting together exert a total force to the left of magnitude

$$2k_x(x_1 - b\,\theta)$$

and a total clockwise moment about the c.g. of magnitude

$$2k_x(x_1 - b\,\theta)\,b$$

The vertical springs are also deformed; the right one being compressed an amount $b\theta$, the left one stretched the same amount. As a result, there is static equilibrium insofar as vertical forces on the c.g. are concerned. The vertical springs, however, do exert a total counterclockwise moment of magnitude $2k_y b^2\theta$ about the center of gravity.

To set up the dynamical equations of equilibrium from which the natural frequencies can be determined, the damping forces and impressed forces and moments will not be considered. Then, for translational equilibrium of the c.g. the governing equation is

$$m_1\ddot{x}_1 + 2\,k_x\,(x_1 - h\,\theta) = 0 \qquad (1)$$

and for rotational equilibrium about the c.g. the governing equation is

$$r^2 m_1\,\ddot{\theta} + 2k_y b^2\,\theta - 2k_x\,(x_1 - h\,\theta)\,h = 0 \qquad (2)$$

Multiply Eq (2) through by b/b^2, obtaining

$$m_1\frac{r^2}{b^2}\,(h\,\ddot{\theta}) + 2\,k_y\,\frac{b^2}{b^2}\,(h\,\theta) - 2\,k_x\,(x_1 - h\,\theta) = 0 \qquad (3)$$

Let

$$h\,\theta = x_2,\; m_1\,\frac{r^2}{b^2} = m_2;\; 2\,k_x = k_1;\; 2\,k_y\,\frac{b^2}{b^2} = k_2 \qquad (4)$$

Then, Eqs (1) and (3) become

$$m_1\ddot{x}_1 + k_1\,(x_1 - x_2) = 0 \qquad (5)$$

$$m_2\ddot{x}_2 + k_2 x_2 - k_1\,(x_1 - x_2) = 0 \qquad (6)$$

To set up the dynamical equations of equilibrium from which the amplitudes of vibration of the machine can be determined, the impressed force and damping forces must be included. In Fig. 1, c_x and c_y are the damping coefficients (lb-sec/in.) of one horizontal dashpot and one vertical dashpot respectively. The impressed force F_1 may be resolved into a horizontal force F_1 acting at th c.g. of the machine and a clockwise moment $F_1 e$ acting about the c.g. The horizontal dashpots will both have the velocities

$$\dot{x}_1 - h\,\dot{\theta}$$

to the right through them; as a result they will exert a total horizontal force to the left of magnitude

$$2\,c_x\,(\dot{x}_1 - h\,\dot{\theta})$$

and a total clockwise moment about the machine c.g. of magnitude

$$2\,c_x\,(\dot{x}_1 - h\,\dot{\theta})\,h$$

The right vertical dashpot will have a downward velocity of $b\dot{\theta}$ through it and the left vertical dashpot an upward velocity of the same magnitude, with the result that a pure counterclockwise moment of magnitude $2\,c_y b^2\dot{\theta}$ is exerted by the vertical dashpots on the machine. Making use of the Relations (4) and introducing the additional relations

$$2c_x = c_1;\; 2c_y\,\frac{b^2}{b^2} = c_2;\; F_2 = \frac{e}{h}\,F_1 \qquad (7)$$

the equations of dynamical equilibrium for the forced translational and rotational motions of the c.g. of the machine are:

$$m_1\ddot{x}_1 + c_1\,(\dot{x}_1 - \dot{x}_2) + k_1\,(x_1 - x_2) - F_1 = 0 \qquad (8)$$

$$m_2\ddot{x}_2 + c_2\dot{x}_2 - c_1\,(\dot{x}_1 - \dot{x}_2) + k_2 x_2 - k_1\,(x_1 - x_2) - F_2 = 0 \qquad (9)$$

Linear Mechanical Analogue

In the two degree of freedom system shown in Fig. 2, mass m_2 is suspended on spring k_2, and mass m_1 is suspended from mass m_2 by means of spring k_1. The damping in spring k_2 is represented by the dashpot c_2 and that in spring k_1 by the dashpot c_1. A vertical external force F_2 is impressed on mass m_2 and a vertical external force F_1 is impressed on mass m_1. It will be shown that the system of two masses suspended on two springs, as shown in Fig. 2, is exactly analogous dynamically to the machine on resilient supports in Fig. 1. Hence, a model of the type shown in Fig. 2 can be studied theoretically, visually or experimentally in the laboratory, and the results of such a study readily translated into frequencies and response of the machine shown in Fig. 1 supported on resilient mounts.

In Fig. 2 let x_1 and x_2 be the displacements of masses m_1 and m_2, respectively, taken positive in the downward direction. Let $\ddot{x}_1$ and $\ddot{x}_2$ be the accelerations of these masses in the downward direction. To set up the dynamical equations of equilibrium from which the natural frequencies of the system of Fig. 2 can be determined, the damping forces and impressed forces will not be considered. The spring k_1 stretches an amount

$$x_1 - x_2$$

and consequently exerts an upward force

$$k_1\,(x_1 - x_2)$$

on the mass m_1 and an equal downward force on m_2. The spring k_2, being stretched an amount x_2, exerts an upward force $k_2 x_2$ on m_2 and an equal downward force on the immovable support. The equations of dynamical equilibrium for the masses m_1 and m_2 are, therefore, respectively:

$$m_1\ddot{x}_1 + k_1\,(x_1 - x_2) = 0 \qquad (10)$$

$$m_2\ddot{x}_2 + k_2 x_2 - k_1\,(x_1 - x_2) = 0 \qquad (11)$$

Comparing Eqs (10) and (11) with Eqs (5) and (6) the analogy between

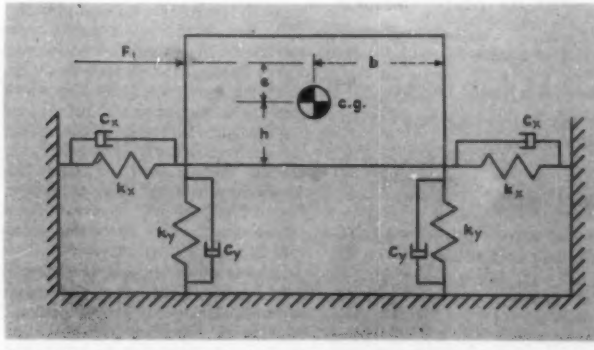


Fig. 1—Common arrangement of a machine on resilient mounts that permits both translational and rotational movement. The impressed force F_1 acting above the center of gravity produces both a force at and a moment about the center of gravity.

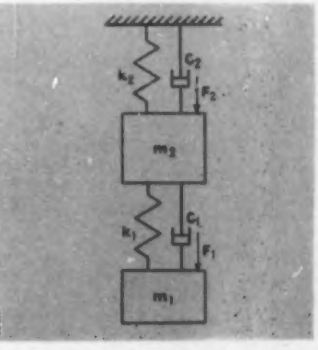


Fig. 2—Linear mechanical analogue for the machine in Fig. 1 for studying the frequencies and response of the system.

the two systems is at once apparent. With corresponding values of the masses and the spring stiffnesses both systems will have identical coupled frequencies. The natural frequencies of the system of Fig. 2 is given by Den Hartog, p 40, "Mechanical Vibrations", third edition, as

$$\omega_{1,2}^2 = \frac{1}{2}\left(\frac{k_1+k_2}{m_2}+\frac{k_1}{m_1}\right) \pm \sqrt{\frac{1}{4}\left(\frac{k_1+k_2}{m_2}+\frac{k_1}{m_1}\right)^2 - \frac{k_1k_2}{m_1m_2}} \quad (12)$$

By substituting into Eq (12) for k_1, k_2, m_2 their equivalents given by the Relations (4), the lower and higher rocking frequencies of the machine in Fig. 1 will be obtained directly in terms of the parameters given in Fig. 1. This equation is given by Den Hartog in "Mechanical Vibrations" as

$$\omega_{1,2}^2 = \frac{1}{2}\left(\frac{2k_a b^2 + k_y b^2}{m_1 r^2}+\frac{2k_a}{m_1}\right) \pm \sqrt{\frac{1}{4}\left(\frac{2k_a b^2 + 2k_y b^2}{m_1 r^2}+\frac{2k_a}{m_1}\right)^2 - \frac{4k_a k_y b^2}{m_1^2 r^2}} \quad (13)$$

In determining the response of the system of Fig. 2 to impressed forces F_1 and F_2, the dynamical equations of equilibrium for m_1 and m_2 will be set up including the damping and impressed forces. The dashpot c_1 has a velocity through it of magnitude

$$\dot{x}_1 - \dot{x}_2$$

so that it exerts an upward force

$$c_1(\dot{x}_1 - \dot{x}_2)$$

on m_1 and an equal downward force on m_2. The dashpot c_2 has the velocity $\dot{x}_2$ through it, so that it exerts an upward force $c_2\dot{x}_2$ on m_2 and an equal downward force on the immovable support. Considering the impressed forces F_1 and F_2 to be positive in the downward direction, the dynamical equations of equilibrium for m_1 and m_2 are, respectively:

$$m_1\ddot{x}_1 + c_1(\dot{x}_1 - \dot{x}_2) + k_1(x_1 - x_2) - F_1 = 0 \quad (14)$$

$$m_2\ddot{x}_2 + c_2\dot{x}_2 - c_1(\dot{x}_1 - \dot{x}_2) + k_2x_2 - k_1(x_1 - x_2) - F_2 = 0 \quad (15)$$

Comparing Eqs (14) and (15) with Eqs (8) and (9) it is evident that a complete analogy exists between the forced motions of the system of Fig. 1 and the forced motions of the system of Fig. 2. If the system of Fig. 2 is designed on the basis of the Relations (4) and (7), then the translational movements of m_1 and m_2 in Fig. 2 correspond, respectively, to the translational and rotational movements of the machine m_1 in Fig. 1. Variations in radius of gyration, in resilient mount stiffnesses or damping, and in mount positions with respect to the machine c.g., show up as variations in the sizes of the suspended weights in Fig. 2, and in the stiffnesses of the springs and coefficients of the dashpots. The exciting force F_1 impressed on the model Fig. 2 corresponds to the force F_1 acting on the c.g. of the machine, and the exciting force F_2 impressed on the model corresponds to the moment impressed on the machine.

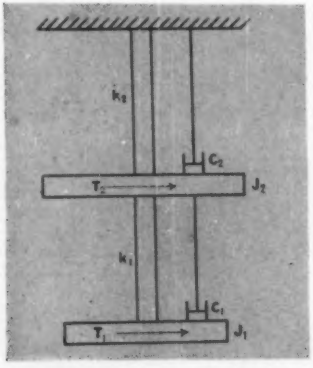


Fig. 3—Torsional mechanical analogue for machine in Fig. 1 for studying the frequencies and response of the system.

Torsional Mechanical Analogue

Another type of mechanical model that can be constructed to represent the machine on its resilient mounts is the two degree of freedom torsional system consisting of two rotational inertias, as shown in Fig. 3. In this model, J_1 and J_2 represent the disk inertias and k_1 and k_2 the corresponding stiffnesses of the shafts in torsion. The impressed forces are torques T_1 and T_2, and the dashpots exert frictional moments on the disks. Thus, the equations of dynamical equilibrium from which the natural frequencies can be determined are:

$$J_1\ddot{\theta}_1 + k_1(\theta_1 - \theta_2) = 0 \quad (16)$$

$$J_2\ddot{\theta}_2 + k_2\theta_2 - k_1(\theta_1 - \theta_2) = 0 \quad (17)$$

Again, the analogy with Eqs (5) and (6) is apparent.

For the case of forced motion of the system of Fig. 3, the equations of dynamical equilibrium are:

$$J_1\ddot{\theta}_1 + c_1(\dot{\theta}_1 - \dot{\theta}_2) + k_1(\theta_1 - \theta_2) - T_1 = 0 \quad (18)$$

$$J_2\ddot{\theta}_2 + c_2\dot{\theta}_2 - c_1(\dot{\theta}_1 - \dot{\theta}_2) + k_2\theta_2 - k_1(\theta_1 - \theta_2) - T_2 = 0 \quad (19)$$

The analogy with Eqs (8) and (9) is evident. In comparing the system of Fig. 3 with that of Fig. 1, the remarks that were made in comparing the system of Fig. 2 with that of Fig. 1 can be repeated substantially.

Mass-Inductance Electrical Analogy

Mechanical models for quantitative experimental work are not always easy to set up and to test. They are excellent for qualitative visual studies. When, however, quantitative results are desired that cover a wide range in variation of mass, inertia, spring stiffnesses, damping and mount positions in order to evaluate optimum arrangements and to determine corresponding vibration amplitudes, no other type of model lends itself so ideally to experimental work as the electrical model.

The entire field of problems governed by Eqs (5) and (6) and by Eqs (8) and (9) can be thoroughly examined quantitatively by means of an electrical analogue.

The circuit diagram shown in Fig. 4 is for an electrical analogue representing the mechanical system of Fig. 1. This type of electrical analogy is called the mass-inductance analogy in that a mechanical mass is represented in the electrical circuit by an inductance. Other corresponding elements of Figs. 1 and 4 are: The spring flexibility (inverse of stiffness) corresponds to the capacitance of a condenser, damping coefficient of a dashpot corresponds to the resistance value of a resistor, force across a spring or acting through a dashpot corresponds, respectively, to the voltage drop across a condenser or across a resistor.

The inertia force exerted by a mass undergoing acceleration corresponds to the voltage drop across an inductor through which a current is changing. The velocity across the ends of a spring, the velocity across a dashpot or the velocity of a mass correspond respectively to the current through a condenser, the current through a resistor or the current through an inductor. The displacement of a mass corresponds to the quantity of electrical charge flowing through an inductor.

To represent the case in which damping and impressed forces are neglected, the corresponding electrical elements, namely, resistance and impressed voltage will be neglected. Thus, the circuit of Fig. 4 becomes that of Fig. 5. It will be shown that a true analogy exists with the corresponding mechanical system.

Assume an instantaneous current i_1 to be flowing in one loop of this circuit and an instantaneous current i_2 in the other loop. Kirchhoff's law for electrical circuits states that the sum of the voltage drops across all elements in a loop must equal zero. Where L_a is the

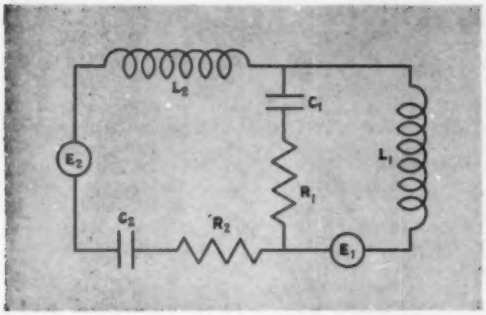


Fig. 4—Electrical analogue circuit for the machine shown in Fig. 1, where an inductance represents a mechanical mass.

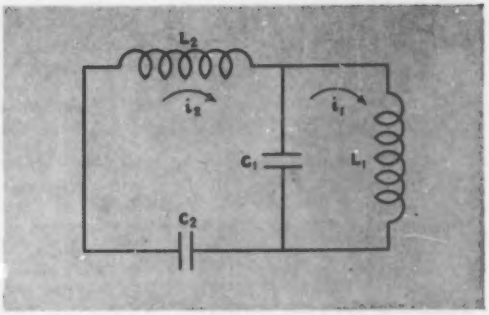


Fig. 5—Circuit diagram for a mass-inductance analogue to study free vibrations of machine supported on resilient mounts.

self-inductance of the inductor in henrys, i_1 and i_2 the currents in amperes, t the time in seconds, and C_1 the capacitance of the condenser in farads, in loop 1 the voltage drop across the inductor is $L_a di_1/dt$ and across the capacitor is

$$\frac{1}{C_1}\int (i_1 - i_2)\,dt$$

In loop 2, the voltage drop across the inductor L_a is $L_a di_2/dt$, across the capacitor C_1 it is

$$-\frac{1}{C_1}\int (i_1 - i_2)\,dt$$

and across the capacitor C_2 it is

$$\frac{1}{C_2}\int i_2\,dt$$

Applying Kirchhoff's law to each loop, the sum of the voltage drops in each case becomes:

$$L_1\frac{di_1}{dt} + \frac{1}{C_1}\int (i_1 - i_2)\,dt = 0 \qquad (20)$$

$$L_2\frac{di_2}{dt} + \frac{1}{C_2}\int i_2\,dt - \frac{1}{C_1}\int (i_1 - i_2)\,dt = 0 \qquad (21)$$

Although Eqs (20) and (21) are exactly analogous to Eqs (5) and (6), the analogy is not immediately apparent. Equations (20) and (21) can be put exactly into the form of Eqs (5) and (6), by using the relation that the rate at which electrical charge flows through a circuit is equal to the current, that is, i equals dq/dt. Corresponding to this, in the mechanical circuit the rate of displacement is equal to velocity, that is, v equals dx/dt. Thus in Eqs (20) and (21), the terms i_1 and i_2 can be replaced respectively by $\dot{q}_1$ and $\dot{q}_2$, so that these equations become

$$L_1\ddot{q}_1 + \frac{1}{C_1}(q_1 - q_2) = 0 \qquad (22)$$

$$L_2\ddot{q}_2 + \frac{1}{C_2}q_2 - \frac{1}{C_1}(q_1 - q_2) = 0 \qquad (23)$$

A comparison of Eqs (22) and (23) with Eqs (5) and (6) reveals immediately the analogy between the two systems. Expressions for the natural frequencies of the electrical circuit can be written by analogy with Eq (12) thus,

$$\omega_n^2 = \frac{1}{2}\left[\left(\frac{1}{C_1}+\frac{1}{C_2}\right)\frac{1}{L_2} + \frac{1}{C_1 L_1}\right] \pm \left\{\frac{1}{4}\left[\left(\frac{1}{C_1}+\frac{1}{C_2}\right)\frac{1}{L_2} + \frac{1}{C_1 L_1}\right]^2 - \frac{1}{C_1 C_2 L_1 L_2}\right\}^{1/2} \qquad (24)$$

Evidently if an electrical model is designed so that

$$\frac{1}{C_1} = k_1\,,\ \frac{1}{C_2} = k_2,\ L_1 = m_1,\ L_2 = m_2 \qquad (25)$$

the electrical circuit would have exactly the same frequencies as the natural rocking frequencies of the machine on its resilient mounts.

This arrangement, however, is not always practical; it may result in very large electrical elements, high voltages and excessive currents. Practical limits, therefore, are set for the values of the electrical circuit elements, and the natural frequencies of the electrical system then take on a predetermined ratio with respect to the natural frequencies of the machine on its mounts. This condition is by no means undesirable. This scale factor effect can be exploited to speed up in the model events that occur too slowly in the prototype and vice versa. For most vibration problems, however, the main advantage of a scale factor resides in making possible an economical model.

When the three fundamental dimensions in the mechanical system are force F, length x, and time t_m the corresponding fundamental dimensions in the electrical system would be voltage E, charge q, and time t_e. The dimensions of all properties in each system can be expressed in terms of the corresponding fundamental dimensions.

In setting up scale factors between mechanical and electrical units, the three scale factors relating the three fundamental dimensions in the two systems can be arbitrarily chosen. Thereafter, all corresponding properties of the two systems are related in terms of these three scale factors. When

F, lb $= a'\,E$, volts

x, in. $= b'\,q$, coulombs

and where t_m and t_e are the times for corresponding events to occur in the two systems

t_m, sec $= c'\,t_e$, sec

Then

$$m,\ \frac{\text{lb-sec}^2}{\text{in.}} = \frac{a'\,(c')^2}{b'}\,L,\ \text{henrys}$$

$$c,\ \frac{\text{lb-sec}}{\text{in.}} = \frac{a'\,c'}{b'}\,R,\ \text{ohms}$$

$$k,\ \frac{\text{lb}}{\text{in.}} = \frac{a'}{b'}\,\frac{1}{C},\ \frac{1}{\text{farads}} \qquad (27)$$

$$\omega_m,\ \frac{1}{\text{sec}} = \frac{1}{c'}\,\omega_e,\ \frac{1}{\text{sec}}$$

$$v,\ \frac{\text{in}}{\text{sec}} = \frac{b'}{c'}\,i,\ \text{amp}$$

The scale factors a', b' and c' can be so chosen that reasonable magnitudes of electrical circuit elements are obtained.

In applying Kirchhoff's law to the circuit of Fig. 4, the following voltage drops are present in addition to those already included in Eqs (22) and (23): The voltage drop across resistor R_1 is

$R_1(i_1 - i_2)$ or $R_1(\dot{q}_1 - \dot{q}_2)$

the voltage drop across resistor R_2 is $R_2 i_2$ or $R_2\dot{q}_2$. There are also sources of potential E_1 and E_2 that must be included in summing voltage drops around each loop. Thus, the governing equations for the flow of electricity

in the circuit of Fig. 4 are:

$$L_1\ddot{q}_1 + R_1(\dot{q}_1 - \dot{q}_2) + \frac{1}{C_1}(q_1 - q_2) - E_1 = 0 \quad (28)$$

$$L_2\ddot{q}_2 + R_2\dot{q}_2 - R_1(\dot{q}_1 - \dot{q}_2) + \frac{1}{C_2}q_2 - \frac{1}{C_1}(q_1 - q_2) - E_2 = 0 \quad (29)$$

The analogy between Eqs (28) and (29) for the electrical circuit and Eqs (8) and (9) for the coupled forced vibrations of a machine on resilient mounts is at once apparent. The impressed voltages E_1 and E_2 correspond to the force and moment exerted on the c.g. of the machine mass. Where E_{c1} and E_{c2} are the voltage drops measured across the capacitors C_1 and C_2, the displacements of the mass can be determined from measurements of voltage drop across the capacitors C_1 and C_2, since q_1 equals C_1E_{c1} and q_2 equals C_2E_{c2}, and so x_1 equals $b'q_1$ and x_2 equals $b'q_2$.

In the electrical analogue shown in Fig. 6, which is set up to study the problem represented in Fig. 1, commercially available electrical units are used. The variable inductor I_2 has a range of 20 to 500 microhenrys and L_1 a range of 0.2 to 5.0 millihenrys. The decade capacitor C_2 has a range of 0 to 0.1 microfarads, and C_1 has a range of 0 to 1.0 microfarads.

A single source of voltage E_1 is shown to simulate the condition wherein the force F_1 acts at the c.g. of the machine mass, so that there is no impressed moment. The voltage source is an oscillator having a range of 35 to 35,000 cps and a peak output of about 30 volts rms. The damping applied to the system is the inherent damping in the circuit elements plus a few ohms introduced by the resistance box V_R, which is used as a voltage divider to prevent overloading of the oscillator. A vacuum tube voltmeter E_{c1} is shown measuring the voltage across condenser C_1. This type of voltmeter has a very high impedance and therefore has no appreciable effect on the behavior of the circuit proper.

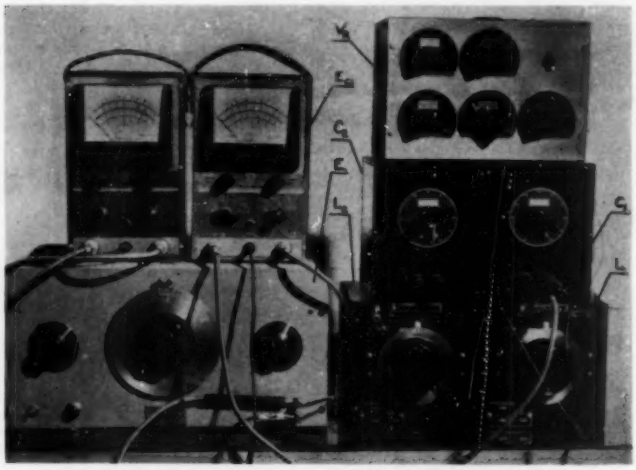


Fig. 6—Analogue computer for vibration isolation problems.

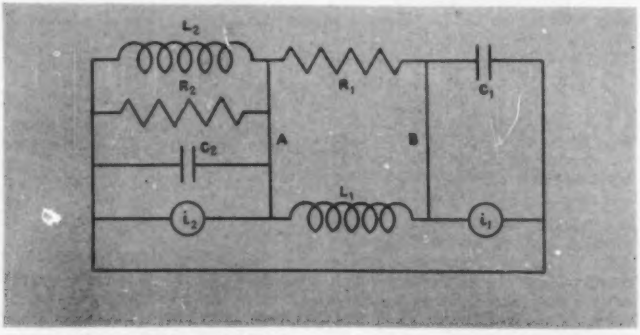


Fig. 7—Diagram of electrical circuit for a mass-capacitance analogue for solution of machine isolation problems. This setup is not as common as the mass-inductance circuit.

Mass-Capacitance Electrical Analogy

A discussion of electrical models for experimental investigation of machine isolation problems would not be complete without the mention of the mass-capacitance electrical analogy. In this model, mass is represented by capacitance, spring flexibility by inductance, viscous damping coefficient by reciprocal resistance, force by current, and velocity by voltage drop. This analogy is somewhat more difficult to operate experimentally and is, therefore, only rarely used as compared with the mass-inductance analogy.

The series circuits of the mass-inductance analogy become the parallel circuits of the mass-capacitance analogy. Fig. 7 shows the circuit diagram for the electrical model of the machine isolation problem using the mass-capacitance analogy. Instead of voltage generators, current generators are shown in the circuit. The voltages E_1 and E_2 are impressed by the current generators i_1 and i_2 across the various elements in the circuits. Kirchhoff's law states that the algebraic sum of the currents entering and leaving a junction is equal to zero. Applying this law to the circuit diagram shown in Fig. 7, the sum of the currents at junction B is given by

$$C_1\dot{E}_1 + \frac{1}{R_1}(E_1 - E_2) + \frac{1}{L_1}\left[\int E_1\,dt - \int E_2\,dt\right] - i_1 = 0 \quad (30)$$

and at junction A by

$$C_2\dot{E}_2 + \frac{1}{R_2}E_2 - \frac{1}{R_1}(E_1 - E_2) + \frac{1}{L_2}\int E_2\,dt - \frac{1}{L_1}\left[\int E_1\,dt - \int E_2\,dt\right] - i_2 = 0 \quad (31)$$

The analogy between Eqs (30) and (31) and Eqs (8) and (9) respectively is evident if in Eqs (8) and (9) x is replaced with v, the mass velocity. Thus, Eqs (8) and (9) become

$$m_1\dot{v}_1 + c_1(v_1 - v_2) + k_1\left[\int v_1\,dt - \int v_2\,dt\right] - F_1 = 0 \quad (32)$$

$$m_2\dot{v}_2 + c_2v_2 - c_1(v_1 - v_2) + k_2\int v_2\,dt - k_1[\int v_1\,dt - \int v_2\,dt] - F_2 = 0 \quad (33)$$

CONCLUSIONS: The coupled vibrations of a machine on its resilient mounts, though difficult to visualize and laborious to analyze theoretically, can be studied conveniently with models. Electrical models are excellent and economical computing machines for evaluating the response of a machine on resilient mounts.

HEAT RESISTANCE of silicone aluminum finishes is far superior to that of conventional finishes pigmented with aluminum powder. Shown above are condition of (A) silicone and (B) oleoresinous finished steel panels after (left) 15 min, and (right) 2 hr exposure to burner temperatures. Decomposition and peeling of the oleoresinous material is apparent in the photographs.

Silicone Surface Coatings

Modified silicone finishes offer a wide range of improved properties including superior stability when exposed to heat, moisture and electrical forces. Specifications, physical and chemical properties are given in detail.

M. A. GLASER
Midland Industrial Finishes Company

SILICONE RESINS offer a solution to the important problem of surface coating failure after prolonged exposure to elevated temperatures.

To obtain the solubility required for conversion to protective coatings the heat-resistant silicon-oxygen molecule is modified with organic groups such as methyl, ethyl and phenyl. In appearance, silicone paints look the same as paints made from conventional vehicles. Silicone finishes can be applied by any of the usual methods—brushing, silk screening, spraying, dipping or roller coating. Exhaust and muffling systems are being dip-coated with silicone-base enamels for protection against heat and corrosive atmospheres.

Silicone-base finishes possess a higher degree of heat-resistance than any other type of solvent coating. The excellent electrical properties of the silicone resins are well known. Silicone wire enamels and impregnating varnishes can be applied as mobile or penetrating liquids, and then baked to form water and heat-resistant insulating compounds having dielectric strengths of 1,500-2,000 volts per mil on thin sections.

Various types of silicone paint are on the market today. For some applications, the heat-resistant properties of silicone resins were supplemented with the desirable features of other compounds to obtain such necessary film characteristics as adhesion, toughness and rapid drying speed. The chemical or physical addition of other monomers and polymers has given rise to the useful class of "modified" silicone finishes.

Pigmented Modified Paints

Two widely used silicone finishes are an aluminum pigmented modified silicone paint and a black pigmented modified silicone paint. Specifications set up by a user of the aluminum pigmented finish, shown in Table I, illustrate its application and durability. Meeting this difficult set of requirements, this silicone-base aluminum has been in large scale production in such applications as: Oil and gas heating equipment; incinerators; mufflers; exhaust systems; electrical equipment; heat exchangers; inside steam retorts;

Table I—Specification of Modified Silicone Aluminum Paint

Metal Treatment	Chemically clean all surfaces (light phosphate coating, grit-blasting, or sand blasting).
Paint Application	Spray or dip paint to dry film thickness of 0.0015 in.
Baking Schedule	10 min at 350 F.
Durability Tests	a. Panels so finished shall withstand a 30 degree bend around a 3/16 in. dia rod at minus 20 F without cracking. b. Panels so finished shall withstand 1,000 F for one hour without showing any signs of deterioration. c. Panels so finished must withstand immersion in water at room temperature for 20 hr without showing signs of blistering or checking. d. Panels so finished must withstand immersion in motor gasoline for 4 hr at room temperature. Within 24 hr after removal from the gasoline, the immersed portion shall be equal in hardness, toughness and film anchorage to the emersed portion. e. Panels so finished must withstand weathering in a weatherometer for 500 hr, without checking, cracking or rusting.

Table II—Abrasion Resistance of Modified Silicone and Conventional Paints

Coating	Baking Schedule	Wear Factor* (Taber Abraser)
Aluminum Modified Silicone	30 min at 250 F	130
Aluminum Modified Silicone	5 min at 370 F	113
Aluminum Modified Silicone	30 min at 350 F	83
Alkyd-Amine White Refrigerator Finish	30 min at 300 F	82

*Higher wear factor indicates poorer abrasion resistance.

high pressure steam lines; lead pots; steel resistor ribbons; furnace casings; arc light reflectors; gas range shields and baffles.

Other tests conducted with the aluminum pigmented modified silicone paint indicate that it will withstand:

Boiling water for 200 hr (bleached slightly)
Salt spray at 95 F for 750 hr
Water fog at 95 F for 750 hr
Outdoor weathering in Florida for 1 year
100 percent relative humidity at 100 F for 1,000 hr
1 percent soap solution for 1,000 hr
10 percent sulfuric acid mist for 100 hr
Heating to dull red heat and plunging in cold water
A 180 deg bend around a ¼ in. rod.

This finish is effective on most metals (properly cleaned), on glass and on ceramic objects. The aluminum pigmented modified silicone finish is used on an oil-burning space heater, constructed of cold and/or hot rolled sheet steel. The silicone finish is subjected to temperatures up to 1,500 F. Use of the silicone-base material has resulted in improved heating efficiency and better appearance during long usage. Use of this same finish on exhaust and muffling systems has resulted in: (1) Much longer life—where ordinary paint was used; and (2) substantial savings—where stainless or aluminum clad steels were used.

Study has revealed that thermal decomposition of silicone finishes commences on prolonged exposure over 700 F. This should be kept in mind where severe salt spray and humidity conditions are to be met in addition to the high temperature exposure. In such applications, use of a specially formulated primer has been found desirable.

Heating increases "cross-linking" or polymerization of silicone resins. This in turn improves certain properties, such as abrasion resistance. Table II shows how the abrasion resistance of the aluminum pigmented modified silicone finish varies with the degree of polymerization.

The black pigmented modified silicone paint is similar to the aluminum finish, and will correspond in practically all its properties. This finish, however, will withstand prolonged heating up to the 600-800 F range only.

Colored Finishes

Colored silicone-base finishes have been developed for a variety of purposes. Yellow, white, orange, red and blue finishes were developed to color or identify glass incandescent bulbs and radio tubes, which attain temperatures no ordinary organic resin materials can withstand. These silicone finishes have particularly good adhesion to glass when baked for 30 min at 400 F or higher.

Research has been undertaken to determine the possibility of developing silicone coating materials to replace porcelain for application on stoves, heaters and similar products. The colors required were black, brown, white and ivory. A survey showed that real economies would result if the proper silicone finishes could be worked out—even at a projected selling price of 25 dollars per gallon. In this survey it was found that, compared with porcelain, silicone finished

Table III—Physical Properties of Silicone and Conventional Finishes

Finish	Baking Schedule	Wear Factor Taber Abraser*	Shear** Hardness	Impact Resistance	100% NaCl at 95 F Salt Spray Resis. 1,000 hrs	20% NaCl at 95 F Salt Spray Resis. 1,000 hrs	Resistance to Weathering (400 hr Atlas Weather-ometer)	Thermo-plasticity at 300 F
Alkyd-Amine White Refrigerator Enl.	30 min at 300 F	82	471	excellent	excellent	excellent	excellent	standard
Alkyd-Amine White Stove Enamel	30 min at 400 F	129	327	fair—good	excellent	excellent	excellent	somewhat more thermo. than std.
Brown Modified Silicone Enamel	30 min at 400 F	75	234	good	excellent	excellent	excellent	less thermoplastic than standard
White Modified Silicone Enamel	30 min at 400 F	245	246	fair—good	excellent	excellent	excellent	equal to standard
Aluminum Modified Silicone	30 min at 350 F	83	357	excellent	excellent	excellent	excellent	less thermoplastic than standard

*higher numerical values indicate poorer wearing properties **higher numerical values indicate greater hardness

stoves: (1) Required a less expensive enamelling steel; (2) required lower baking temperatures; (3) gave fewer rejects due to chipping; (4) could be easily repaired; and (5) could be finished in plants that found it necessary to send out porcelain enamelling work.

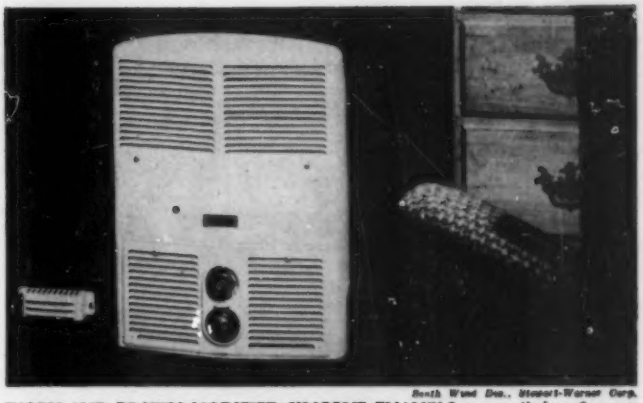
After it was determined that silicone-base enamels in these colors would withstand temperatures approaching 500 F indefinitely without apparent change, a series of tests was instituted, evaluating some silicone enamels against two conventional alkyd-amine white enamels. Table III shows results of these physical tests. The white modified silicone enamel was then further tested. Panels baked as indicated in Table III, were subjected to a group of chemical reagents; Table IV shows their effect on the silicone finish.

The superior gloss retention properties of the silicone type white enamel on prolonged heating are striking. The accompanying curves show gloss retention on heating of various enamels.

However, because silicone finishes are not as abrasion resistant or as hard as porcelain, indicated stove applications are for sides, front and back. If bearing surfaces, where utensils are apt to be placed and dragged, are not of porcelain, a non-skid silicone rubber top is suggested.

Ivory and brown modified silicone enamels have recently been adopted for finishing room air heaters exposed to 485 F temperatures. The manufacturer's engineering department determined that these finishes must: (a) Have high gloss; (b) resemble baked enamel surfaces; (c) withstand 485 F temperatures without appreciable discoloration or softening; and (d) be applied by spray over cleaned aluminum panels. Touching-up of heaters rejected because of dust and lint calls for light scuffing with sandpaper, a spray coat of some enamel, and recycling through the oven at the 400 F minimum original baking temperature.

Silicone finishes have outdoor durability far surpassing other organic finishes now available. Although their present cost makes them prohibitive for use on passenger automobiles, these paints should be of interest to manufacturers of outdoor signs, and to other industries where initial paint material cost is not the determining factor. However, since they are made from a low-cost, abundant material—silica—silicone resins and their derivatives are bound to come down in price. In that event, silicone finishes could be applied to a wide variety of products, including refrigerators, washing machines and automobiles.

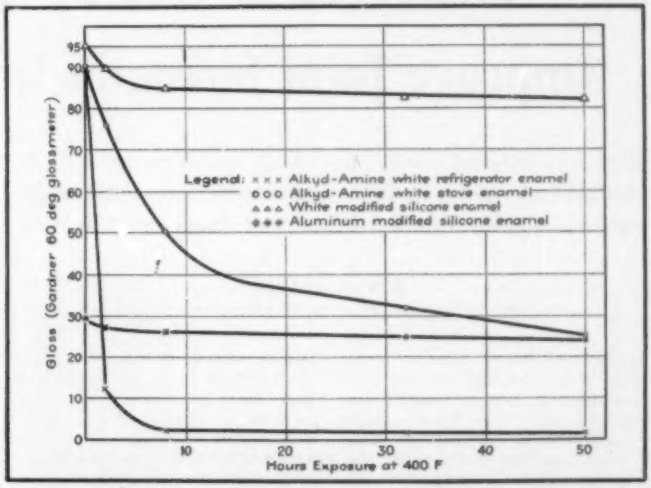


South Wind Div., Stewart-Warner Corp.

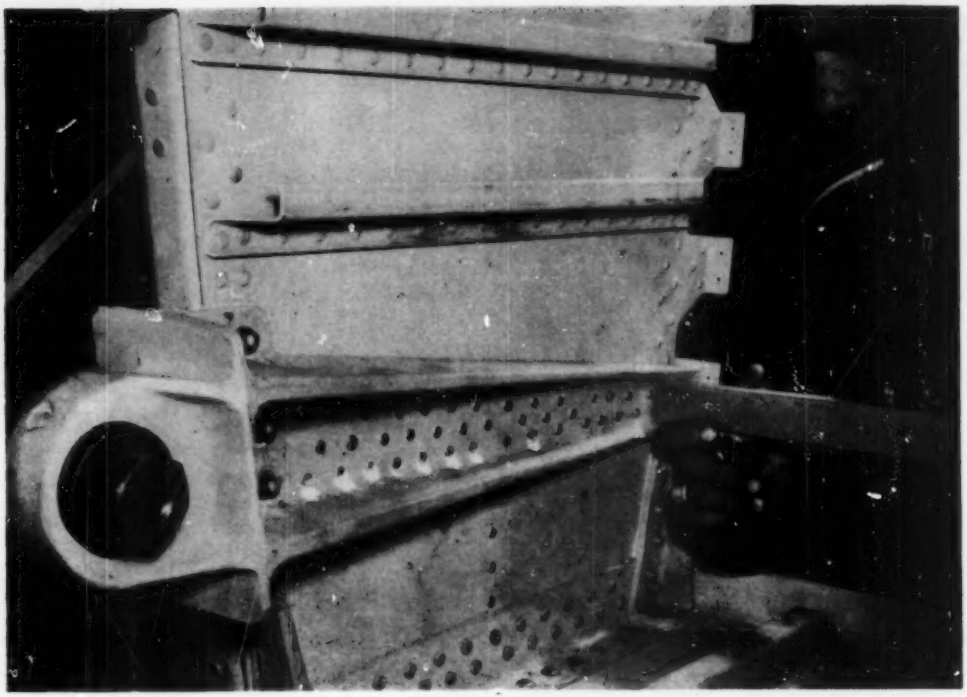
IVORY AND BROWN MODIFIED SILICONE ENAMELS are applied to Stewart-Warner gas-burning room heaters. Sprayed over aluminum, these finishes resemble baked enamel and withstand 485 F temperatures without discoloration or softening.

Table IV—Chemical Tests on White Modified Silicone Enamel (baked 30 min at 400 F, all exposures for 100 hr)

Exposed to	Result
Motor oil SAE 10	unaffected
1% Soap solution	unaffected
1% Caustic Soda solution	unaffected
5% Caustic Soda solution	stained, film ok
1% Hydrochloric Acid solution	unaffected
5% Hydrochloric Acid solution	unaffected
1% Sulfuric Acid solution	unaffected
5% Citric Acid solution	unaffected
Oleic Acid	very slightly softened
5% Tri Sodium Phosphate	unaffected



GLOSS RETENTION of silicone and other synthetic resin enamels, after heating at 400 F. Enamels were sprayed over 20 gage cold-rolled steel; see Table III for baking schedule. Superior gloss retention of silicone type white enamel is striking.



FASTENING the main landing gear forging to the wing of a Convair-Liner with stainless steel rivets. Chief advantage of stainless steel as a rivet material is a shear strength considerably higher than the metals commonly used for this purpose.

Stainless Steel Rivets

Improve Joint Strengths in Aluminum

Effect of alloy variations and head shape on the strength and upsetting characteristics of stainless steel rivets, and on the fatigue resistance and the corrosion resistance of sheets joined by them.

ROY A. MILLER
Structural Design Specialist, Consolidated-Vultee Aircraft Corp.

WHEN CHOOSING A RIVETING MATERIAL for use with high strength structural sheet or plate, the problem is to select a material: (1) Whose strength is approximately equal to or better than the sheet that is to be joined; and (2) that can be formed into a rivet and driven in place without considerable increase in brittleness due to cold working. Such requirements are, in general, necessary for the rivets of any structure that is to be subjected to heavy loads, but they are particularly important in aircraft where severe dynamic loads and high strength to weight ratios make undesirable a compromise on either one or the other.

Consequently, a test program was undertaken at Consolidated-Vultee Aircraft Corporation, San Diego, California, to determine the suitability of annealed stainless steel rivets for joining clad 75S-T6 aluminum and AISI 4130 alloy steel sheet. The rivet material used in the investigations conformed to type 304 stainless steel, and was obtained in the form of wire in the annealed condition. After the rivets were formed in the heading machine, most were annealed, sandblasted, pickled, and cadmium plated before being driven in the test specimens.

Properties Investigated

Tests were conducted to determine the ultimate shear strength of different types and sizes of annealed rivets in various sheet materials, the force required to drive the rivet, the effect of

annealing the rivet after the cold heading operation, the effect of edge distance and rivet spacing on cracking of adjacent material, and the effect of the rivet on the corrosion and fatigue resistance of the adjacent sheet. The results of these tests can be summarized as follows:

TYPE OF SHEET AND RIVET MATERIAL. Shear tests of joints in clad 75S-T6 aluminum and in 4130 steel sheet heat-treated to an utlimate tensile strength of 175,000 psi are summarized in Table I. The shear specimens consisted of flat strips of sheet material joined by a single rivet to form a single or a double shear lap joint, as shown in Fig. 1. The rivets were driven to a flat head, the diameter of which was equal to 1½ the shank diameter. Rivet holes in the sheet were drilled to 0.1285 in. for a ⅛ in. rivet, 0.159 in. for a $\frac{5}{32}$ in. rivet, and to standard dimensions for other rivet diameters.

Results indicate that the shear strength of these rivets, both at yield and at ultimate, is greater when driven in clad 75S-T6 aluminum sheet than when driven in AISI 4130 steel sheet, the yield strength in this case being assumed to be the load at a permanent set equal to 4.0 percent of the rivet shank diameter. The reason for this difference in strength is probably due to the fact that the rivet shank expands more in the aluminum sheet, which is softer, than in the steel sheet; since the rivet is larger and is cold worked to a greater extent, it has greater actual strength.

Table I—Shear Strength of Joints Made With Stainless Steel Rivets[1]

Rivet						Shear Strength at Joint, psi			
Size, in.	Condition	Alloying Elements, Percent			Chromium-Nickel Ratio	75S-T6 Aluminum		AISI 4130 Steel	
		Chromium	Nickel	Carboa		Ultimate	Yield	Ultimate	Yield
5/32	Annealed	16.95	7.91	0.11	2.143	130,520	61,300	105,600	54,875
5/32	Annealed	18.73	8.29	0.07	2.260	117,330	54,225	97,875	58,000
1/8	Annealed	18.40	8.71	0.07	2.112	96,410		90,160	
5/16	Annealed	18.80	8.81	0.07	2.134	105,560		88,080	
5/16	Annealed	18.03	9.20	0.08	1.960	101,000			
1/4	Annealed	18.20	9.20	0.08	1.978	99,660		86,400	
1/4	Annealed	18.60	9.30	0.075	2.000	103,450			
5/16	Annealed	18.60	9.30	0.08	2.000	98,480		89,850	
3/8	Annealed	17.78	9.32	0.095	1.908	92,350		84,875	
5/32	Annealed	19.50	9.54	0.07	2.004	110,720		98,475	
1/4	Annealed	18.80	10.30	0.07	1.825	87,630			
1/4	Annealed	18.75	10.32	0.08	1.817	88,800	42,650	77,460	43,500
5/16	Annealed	18.75	10.32	0.08	1.817	88,560		77,400	
3/16	Annealed	18.00	10.40	0.07	1.731	91,850			
1/8	Annealed	18.30	11.29	0.097	1.620	87,940		89,260	
1/4	Annealed	17.85	11.42	0.065	1.564	83,035			
5/32	Not Annealed	16.95	7.91	0.11	2.143	147,875	87,475	115,750	77,800
5/32	Not Annealed	18.73	8.29	0.07	2.260	118,100	68,800	97,600	59,000
5/16	Not Annealed	17.40	9.22	0.075	1.887			82,200	51,000
1/4	Not Annealed	18.75	10.16	0.06	1.846			74,500	50,200
1/4	Not Annealed	18.80	10.30	0.07	1.825	90,000			
1/4	Not Annealed	18.75	10.32	0.08	1.817	97,175	60,475	79,150	53,350
1/4	Not Annealed	18.60	10.51	0.04	1.770	83,800	52,700	73,800	50,700

[1] All rivets with solid shanks, and driven to a 1 1/3 D flat head.

The general trends of the yield and ultimate shear strengths of the rivets with variations in the amounts of the chief alloying constituents—chromium, nickel, and carbon—also are shown in the table. A graph of this information was plotted, Fig. 2, for the specimens in which the carbon content varied between 0.065 and 0.08 percent, the shear strength being plotted in terms of the chromium-nickel ratio. These curves show that shear strength increases with an increase in the chromium-nickel ratio. A comparison of the data of Table I with the curves of Fig. 2 indicates that a greater increase in shear strength may be expected through the use of larger amounts of carbon when the chromium-nickel ratio is large; the effect of variations in the carbon content within the range of these tests is almost negligible when the ratio is small. For example, if the chromium-nickel ratio were a minimum of 2.3 and the carbon content a minimum of 0.08 percent, the rivets would be expected to have a design shear strength of 90,000 psi when driven in 4130 steel, and of 100,000 psi when driven in clad 75S-T6 aluminum. This would require an approximate alloy range of 19 to 20 percent chromium, 7.75 to 8.25 percent nickel and 0.08 to 0.12 percent carbon, and would result in a special steel with resultant difficulties in procurement. It is therefore desirable to adopt a lower design shear strength—one that can be readily met by a steel procured from current available sources.

Assume that a rivet made from annealed wire is to be driven to a 1-½ diameter flat head. Also assume a design ultimate shear strength of 75,000 psi. The decrease from the suggested values of 90,000 psi and 100,000 psi in 4130 steel and in clad 75S-T6,

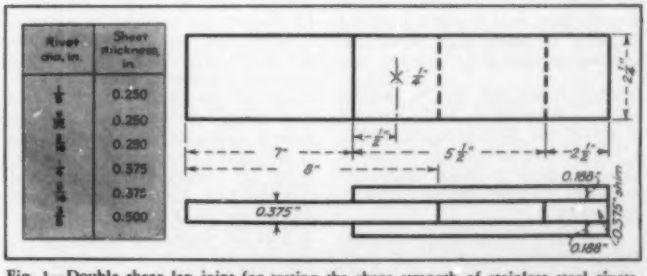


Fig. 1—Double shear lap joint for testing the shear strength of stainless steel rivets. Rivet diameters used for sheets of different thickness are shown in the chart.

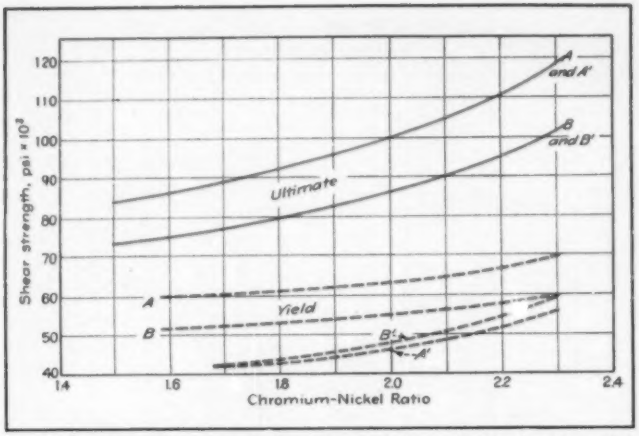


Fig. 2—Variation in shear strength of stainless steel rivets with the chromium-nickel ratio. Curve *A* indicates strength of non-heat treated rivets in 75S-T aluminum sheets; A^1, of annealed rivets in 75S-T sheets; *B* of non heat-treated rivets in 4130 steel having a strength of 175,000 psi; and B^1 of annealed rivets in 4130 sheet.

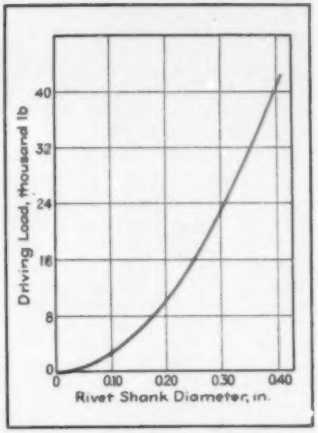


Fig. 3—Force required to drive stainless steel rivets having a solid shank and a head diameter 1-1/3 times the shank diameter in clad 75S-T aluminum sheet.

respectively, would not seriously affect the number of rivets required except with relatively thick materials. A shear strength of 75,000 psi can readily be met by a rivet with a chromium-nickel ratio of 1.8 and a carbon content of 0.06 percent minimum. Type 304 steel meets this requirement except that the carbon content would need to be changed from 0.08 percent maximum to a 0.06 percent minimum and 0.12 percent max. From the curves of Fig. 2, it is apparent that such an alloy would have an ultimate shear strength of at least 76,000 psi when driven in 4130 steel sheet and 83,000 psi when driven in clad 75S-T6 sheet.

Tension tests of these rivets were also conducted. It is of interest to note that the stainless steel rivet with a 1-¼ diameter flat head formed from a solid shank, or from a shank with a centered shallow round hole in the end, will show a greater tensile strength than shear strength, provided the sheet in which it is driven has sufficient strength and stiffness.

DRIVING FORCE FOR RIVETS. Besides having a major affect on the strength of a rivet, the alloying constituents to a large extent govern the force required to drive it. Head dimensions and shank diameter also are contributing factors.

With Type 304 stainless steel rivets having the alloying constituents present in the amounts previously recommended, a force of approximately 9,900 lbs is required to upset a $\frac{3}{16}$ in. rivet to a flat head, provided that the head diameter is 1½ times the shank diameter, that the length of the extended shank from which the upset head is formed is about 1½ times the shank diameter, and that the material is not annealed subsequent to the heading operation. Within the range of these tests, there was no consistent relationship between the driving load and the chromium-nickel ratio; however, the load does increase somewhat with an increase in carbon content. Also, it was found that annealing the rivet between the heading and upsetting operations decreases the upsetting load about 4.0 percent.

The force required to drive rivets of other diameters varys with the area of the shank, as shown in Fig. 3. As the shank diameter becomes greater, a point is reached at which the capacity of gun drivers is insufficient and even that of squeezers might be exceeded. To decrease the force that is required, a round hole can be formed in the end of the rivet shank. The driving load and the shear strength both decrease with the size and depth of this hole, but it becomes more difficult to form a satisfactory symmetrical head as the shank hole increases in size and depth. As a result, it is recommended that the hole have a diameter half that of the shank and a depth equal to ⅜ of the shank diameter. In riveting to a 1-⅓ diameter flat head, this centered shank hole reduces the upsetting load by 26 percent in all materials. The squeezer load necessary to drive a rivet with a hole of the above dimensions in the end of the shank thus becomes about 7400 pounds for a $\frac{3}{16}$ in. rivet. The decrease in cold work because of the reduced driving load reduces the shear strength about 7-½ percent when a rivet driven in clad 75S-T6 aluminum sheet and about 2.5 percent when it is driven in heat treated 4130 steel sheet.

Before adopting the 1⅓ diameter head, specimens were made and tested in which the rivet was driven in clad aluminum sheet to a head size of 1½ diameters. The averages of the test results showed that this increase in head size increased the driving load about 36.6 percent, and the shear strength about 6 percent. The increase in strength is assumed to be due to the additional cold work in forcing the shank into an expanding hole in the softer aluminum alloy sheet. However, the large increase in upsetting load was considered not to be justified by the small increase in shear strength.

EFFECT OF COLD WORK. The effect of the cold work associated with the driving operation in increasing the shear strength of stainless steel rivets is indicated in Fig. 4. These curves show an appreciable increase in unit shear strength with over-sized holes due to cold work, and due also, probably, to hole enlargement and increase in rivet shank under the driving loads. For example, the nominal hole diameter for a ¼ in. rivet is 0.257 in. With

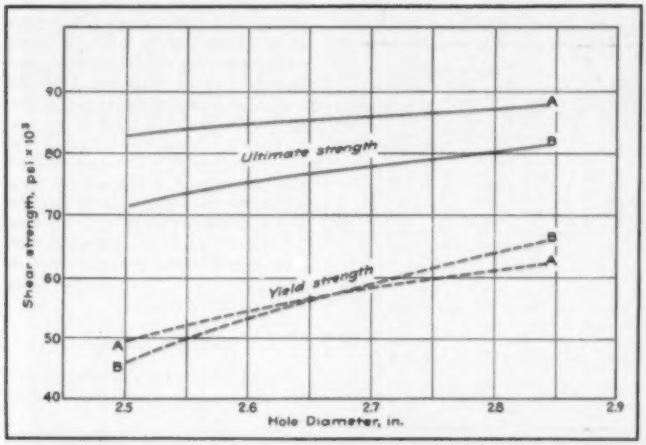


Fig. 4—Variation in shear strength of stainless steel rivets with hole size. Original shank diameters were 0.250 in. Curves *A* are for rivets in 75S-T aluminum sheet, and curves *B*, for rivets in AISI 4130 sheet having 175,000 psi ultimate strength. Increase in shear strength is due to cold work and increase in shank dia during driving.

a hole 0.275 in. dia—10 percent over the nominal rivet dia—the shear strength is 4.2 percent better in clad 75S-T6 aluminum and 8.0 percent better in 4130 steel sheet.

The result of other tests to determine the hole filling ability of $\frac{5}{16}$ in. rivets in $\frac{3}{8}$ in. plate indicated that the rivets would completely fill holes that were 10 percent oversize, and would fill others 13 percent oversize (0.040 in.) sufficiently to justify confidence in a satisfactory joint.

ANNEALING. In all of the initial tests, the rivets were annealed after the heading operation to make them easier to drive, it being thought that otherwise they might crack due to induced stresses caused by work hardening. Later tests, however, indicated this not to be true, so sufficient data was subsequently obtained to show the shear strength at yield and at ultimate for rivets not annealed.

When the rivets are driven in clad 75S-T sheet, the elimination of the annealing operation results in an average increase in driving load of about 4 percent, an average increase in ultimate shear strength of 7.0 percent, and an average increase in yield shear strength of 37 percent. These increases mean that the yield is raised with respect to ultimate so that the ratio of yield to ultimate shear strength becomes about 0.620 when the rivet is driven in clad aluminum. The increase in driving load is negligible. Allowing for these changes, the design values for 1½D head rivets in clad 75S-T sheet and with an upper limit of 9½ nickel would be 98,500 psi for shear ultimate and 61,000 psi for shear at yield.

EFFECT OF PLATING. The reaction of rivets in the presence of corrosive agents, when driven in aluminum alloys, is of considerable concern and a number of tests were made to observe the effect. Early tests had shown the importance of cadmium plating, so all the rivets were cadmium plated. Lap joints in clad 75S-T6 sheet were exposed for various lengths of time in a standard salt spray cabinet with a 20 percent salt solution at 95 F and then tested to destruction. The specimens were so designed that the failures would be sheet failures. No loss in strength was noted, even after 300 hours of exposure, except in the case of one series in which the joint material was a 75S-T6 extrusion not anodized or primed. The joints were also tested for stress corrosion effects by spotfacing the sheet 0.011 in. deep for a diameter of $\frac{1}{4}$ in. at the rivet prior to riveting. After boiling the spotfaced specimens for 24 hrs. in a 6 percent salt solution, they were milled to a depth of 0.222 in. below the clad surface, polished, and metallographically examined for evidence of stress corrosion cracking both in the etched and unetched conditions. No cracks or evidence of corrosive effects were noted. These tests indicate that cadmium plating will afford adequate corrosion protection for most purposes.

However, to obtain good adherence of the plate it was necessary to sandblast the rivets even though they were not annealed after the heading operation; to pickle them for 30 minutes in a 50 percent hydrochloric acid solution; and to hold the rivets for 30 minutes in a standard plating solution. It was found that the plating thickness could be increased by increasing the time in the plating solution from 30 to 40 minutes, but it was also noted that the plating then exhibited a tendency to blister and flake off. The resulting plating thickness was measured on a number of specimens by immersion in a solution consisting of antimony trioxide and hydrochloric acid. By comparing the time required for the acid to eat through the plating with a chart established through a series of precise tests, it was found that a thickness of 1½ to 1¾ ten-thousandths results from the above treatment, that this thickness is reduced about one-quarter in the driving operation, and that the plating thickness is reduced slightly more when the rivet is gun driven than when squeezer driven. These thicknesses admittedly are not as great as is considered desirable for steel parts used in contact with aluminum alloy materials, but tests have shown that the corrosion resistance of such combinations is satisfactory when the plating procedure has been as outlined.

EFFECT ON LIFE OF STRUCTURE. A series of fatigue tests also was conducted to determine if the use of stainless steel rivets would in any way decrease the service life of the structure.

The fatigue tests were conducted with specimens consisting of single shear lap joints containing two $\frac{5}{16}$ in. rivets in tandem on the main axis of the specimen. The rivets were spaced at $\frac{3}{4}$ in. and had an edge distance of 2.5 diameters. The sheet material consisted of strips of $\frac{3}{4}$ x 0.064 in. clad 75S-T6 sheet. The fatigue machine, with test specimens in place for simple material tests, is shown in Fig. 5. With this set-up, four specimens were tested simultaneously. The load was applied by means of a mass mounted on an eccentric arm on a shaft, the front support of the shaft being in the bearing. The bearing is supported by the square plate, which in turn is supported by the four test specimens. The eccentric weight is just back of the front fixture plate. The rear support of the shaft was in the steel structure and at the motor that drove it. By the use of a suitable speed and mass of the eccentric weight, and through the use of appro-

Table II—Fatigue Strength of Riveted Joints

Type of Specimen	Max. Stress, psi	Stress Ratio	Cycles to Failure		
			Virgin Specimen	Corroded Specimen	Loss from Corrosion, percent
Hi-shear rivets	+31,500	+1.68	75,710	52,370	30.8
AN-3 steel bolts[1]	+31,500	+1.68	61,020	48,735	20.1
24S-T31-1½ D flat head rivets	+31,500	+1.68	36,630	39,790	7.90 (gain)
Stainless steel rivets—1 1/3 D flat head with centered hole	+31,500	+1.68	62,670	46,570	25.7
Stainless steel rivets—1 1/3 D flat head	+31,500	+1.68	55,250	36,960	30.1
Stainless steel rivets—1 1/3 D flat head (rivet primed)	+31,500	+1.68	63,720	46,800	26.55
Stainless steel rivets—1 1/3 D flat head (rivet primed, sheet anodized and primed)	+31,500	+1.68	56,520	37,665	33.4
Stainless steel rivets—1½ D flat head	+31,500	+1.68	49,390	49,050	0.7
Stainless steel—AN-426 head[1]	+25,000	+0.24	87,750	66,520	24.2

[1] *AN* refers to Army-Navy Specifications.

priate initial tension, the desired stress cycle could be obtained. The accuracy of the stresses being imposed on the specimen was checked in each case by means of strain gages and a recording oscillograph.

The resulting data are summarized in Table II; each value is the average of a number of tests to failure, 5 tests in one case and 8 to 13 tests for the others. A duplicate series of specimens also was tested in the fatigue machine after boiling them for 12 hrs. in a 6 percent salt solution. For purposes of comparison, specimens were also built and tested in which the joint was completed with a 24S-T6 rivet, a Hi-shear rivet, and with an AN-3 bolt. In all specimens 75S-T6 sheet was used. The results of the tests with 24S-T31 rivets appear to be out of line, yet the results are each the average of 12 tests in which the scatter was on the order of plus or minus 40 percent. Thus, it can be concluded that the use of stainless steel rivets driven in clad 75S-T6 results in a small reduction in the fatigue life of the joint, compared with that of joints made with bolts or Hi-shear rivets, but that a corrosive exposure causes about the same percent reduction in fatigue life in any case.

OTHER LIMITATIONS. It is to be expected that stainless steel rivets, due to their hardness and the loads required to drive them, would have certain limitations, and other tests were conducted to establish these limitations. The tests indicated that these rivets should not be used in brittle materials such as 195T-6 castings, and that the use of washers under the upset head is of little assistance in preventing cracks. These tests also showed that it is desirable to maintain a rivet spacing of 3 diameters and an edge distance of 2 diameters. It is further recommended that they not be used with protruding heads or machine countersunk heads in thin aluminum alloy sheet, although their use in dimpled joints in thin sheet has been entirely satisfactory.

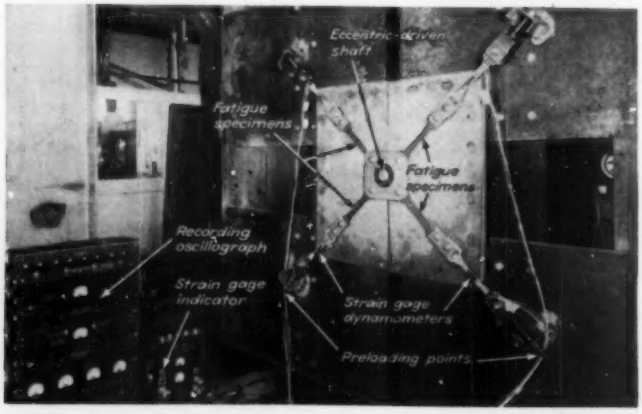


Fig. 5—Fatigue testing machine with which four specimens can be tested to failure simultaneously. Loading is checked with strain gages and a recording oscillograph.

Recommendations

Recapitulating, the following recommendations apply when stainless steel rivets are used:

1. The wire for the rivets should be procured in the annealed condition; be of cold-heading quality; and have a chromium content between 18 and 20 percent, a nickel content between 8 and 10 percent, and a carbon content between 0.06 and 0.12 percent.

2. The rivets should be headed in a rivet machine without a subsequent annealing operation, but they should then be sandblasted, pickled and cadmium plated.

3. The rivets should be driven or upset to a flat head, the diameter of which is 1½ of the shank diameter. The length of the extended shank from which the upset head is to be formed should be equal to 1¼ to 1½ of the shank diameter. To relieve the upsetting loads for the larger rivets, a centered hole may be provided in the end of the shank. This hole should have a diameter half that of the shank, and a depth equal to ⅝ of the shank diameter.

4. The ultimate design shear strength of a protruding head rivet will be at least 75,000 psi. When driven as a flush rivet, the shear strength will depend somewhat on the sheet thickness and strength. Tensile strength will be at least equal to its shear strength.

5. This rivet should be used with a minimum spacing of 3 diameters and a minimum edge distance of 2 diameters. It should not be used in brittle materials such as cast 195-T6 aluminum. It should not be used as a protruding head rivet nor as a machine countersunk rivet in aluminum alloy sheet less than 0.051 in. thick.

6. The corrosion resistance of joints in 75S-T material will be satisfactory, providing the rivets are properly cadmium plated.

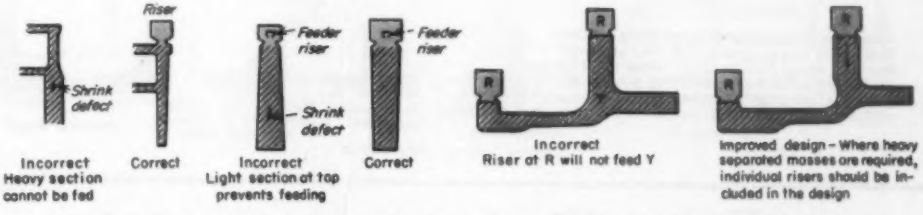
7. The fatigue life of structures will not be seriously impaired.

How Design Is Affected By Foundry Practice

10 BASIC RULES which the designer should follow to facilitate production of sand cast metal parts. Although these rules should not be applied mechanically, their judicious use will lead to a sounder and more economical product. In addition to specific rules relating to shape and size of a part, reasons for the influence of casting problems on product design—such as shrinkage allowance—are explained in detail.

OLIVER SMALLEY, Meehanite Metal Corporation

RULE 1— Design for Sound Castings



Incorrect Heavy section cannot be fed

Correct

Incorrect Light section at top prevents feeding

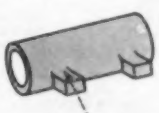
Correct

Incorrect Riser at R will not feed Y

Improved design – Where heavy separated masses are required, individual risers should be included in the design

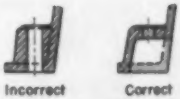
To offset liquid shrinkage, design so that all members of the parts increase progressively in thickness to one or more suitable locations where risers (feeder heads) can be placed to supply the metal required. These are illustrations of correct and incorrect methods of designing to assure soundness of section.

RULE 2— Design Sections as Uniform in Thickness as Possible



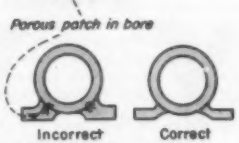
All heavy sections should be accessible for feeding – see Rule 1.

Uniform section saves weight, material, machining costs and results in stronger casting ---→



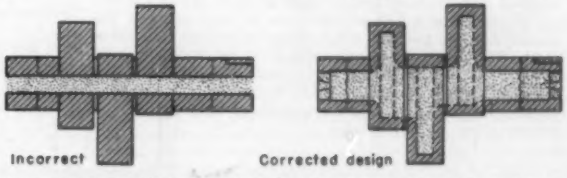
Incorrect

Correct



Incorrect Porous spots Weak foot Cylinder with lugs

Correct design



Incorrect

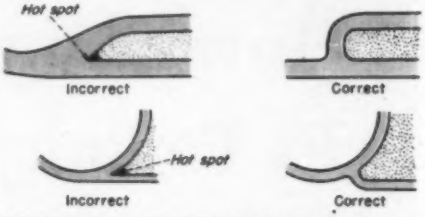
Corrected design

Hydraulic Pump – Designed originally with 2 in. core through center. This gave excessive metal and porous patches on machined casting.

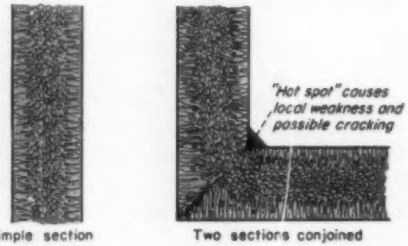
(continued on next page)

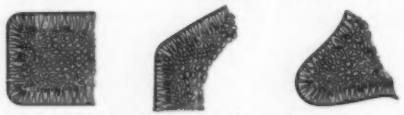
RULE 3 — At Adjoining Sections Avoid Sharp Angles And Abrupt Section Changes

Metal Structure is Affected by Shape of Casting Section. Solidification of molten metal always proceeds from the mold face, forming unbalanced crystal grains that penetrate into the mass at right angles to the plane of cooling surface. A simple section presents uniform cooling conditions and greatest freedom from mechanical weakness. When two or more sections conjoin, mechanical weakness is induced at the junction and free cooling is interrupted, creating a "hot spot."

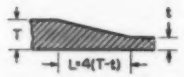


Cylinder castings (marine cylinder port core.) Avoid core design that does not present a cooling surface.





Crystal structure of various casting forms shows advantages of rounded corners. The extent of formation of columnar crystals is primarily a function of the metal used, the rate of solidification and the shape of the casting.



Avoid Abrupt Section Changes. The difference in the thickness of adjoining sections should be a minimum and not exceed a ratio of 2:1. Where a greater difference is unavoidable, consider design with detachable parts—ways of machine tool beds can be bolted. When a change of thickness is less than 2:1, it may take the form of a fillet; where the difference is greater, the recommended form is a wedge. Wedge-shaped changes in wall thickness should be designed with a taper not exceeding 1:4. Where light and heavy sections are unavoidable, use proper fillets or tapering sections or both. If blending of sections is not possible, use fillets of fairly large size at junctions.

Avoid stress concentration at adjoining sections. Replace all sharp corners with radii and avoid heat and stress concentration. When the thickness of flanges differ from that of the body of the casting, the change in thickness should be gradual and tapered 1:4.5.

Local structural weakness
Local shrink weakness
Too large fillet causes weak metal structure or shrinkage defect
Improved design
Poor design

RULE 4 — Fillet All Sharp Angles

Fillets have two functional purposes: (1) To reduce stress-concentration in the casting in service; and (2) to prevent cracks, tears and draws at re-entry angles; to make corners more moldable.

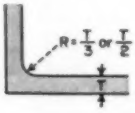
To fulfill engineering stress requirements and reduce stress concentration relatively large fillets should be used:

$R = T$ to $2T$

where $R =$ radius of fillet

$T =$ thickness of casting

However, where this dimension fillet is used, casting thickness is increased at the joint and tends to cause structural weakness in casting. Casting design should preferably take the form shown as "improved" design of L section. Where this is not possible, it should be decided whether the engineering design or the foundry casting problem is most vital. From the foundryman's viewpoint, too large fillets are undesirable and the radius of the fillet should approximate one-third the thickness of the section joined.



L Section

Shrink or draw
Fillet too large—causes shrinkage porosity or weak metal structure
Improved—uniform cooling rate obtained

V or Y Section

RULE 5 — Bring Minimum Number of Adjoining Sections Together

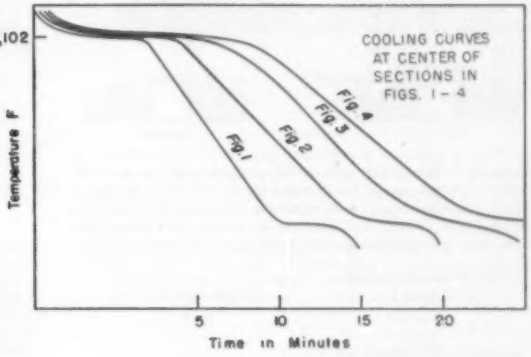
In a well designed casting, sections are no thicker than is essential to the desired unit of strength and are evenly proportioned to avoid local slow cooling.

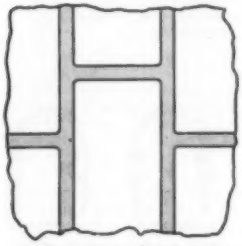
Fig. 1—Simple section cools freely from all surfaces.

Fig. 2—Adding a second section creates "hot spots" shown; area inside circle cools at rate of section 50 percent larger.

Fig. 3—When two sections cross, only material outside circle represents true properties. Area inside circle solidifies at the rate of a bar twice its cross-sectional area.

Fig. 4—Adding too large fillets aggravates defect.

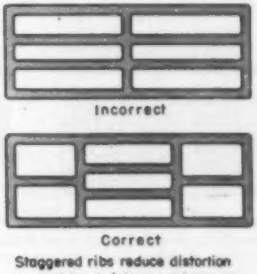




Avoid concentration of metal by staggering cross-members or ribs.

Cored hole speeds cooling at joint.

Circular web with ribs good on large flat plates. Section of circular web may be smaller than section of the ribs.



Staggered ribs reduce distortion caused by shrinkage and concentration of metal, and minimize "hot spots."

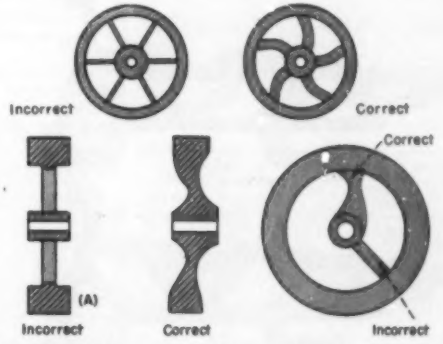
RULE 6 — Avoid Casting Strain

Casting design creating a variation in cooling rates between its different parts is the commonest cause of casting strain. Cracks, distortion and structural weakness usually result from differential or hindered solid contraction. When a casting cools from solidification to room temperature it contracts but at the critical carbide change there may occur a marked expansion, followed again by normal contraction. To reduce or prevent casting strain:[1]

1. Avoid sudden changes of form producing a corresponding change in the direction of shrinkage.
2. Avoid re-entrant angles.
3. Avoid multiplicity of cores—these expand under influence of heat and offer resistance to free shrinkage.
4. Avoid widely differing section sizes—especially those in close juxtaposition—which might give rise to different rates of cooling.
5. Where internal casting strain must be a minimum or where complete stability is vital, provide for a stress relief anneal.

When designing gears, flywheels and spoked wheels:

1. Use odd number and curved spokes.
2. Provide for all cross-sections to cool as evenly as possible by avoiding excessive sectional variation.
3. Blend sections of varying sizes carefully.



The rim of the flywheel (A) is designed heavier than the spokes, and when poured solidifies last. Due to restrained contraction and cooling of the uneven sections, the rim will be left with tension strains, with corresponding compression forces in the spokes and hub. Arms of sufficient section, having a cooling rate more nearly that of the hub and rim, represents good design.

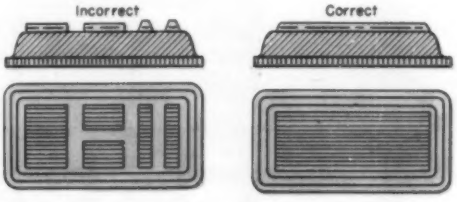
(*continued on next page*)

RULE 7 — Bosses, Lugs and Pads Should Not Be Used Unless Absolutely Necessary

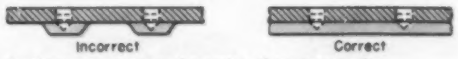
Bosses and pads increase metal thickness, create hot spots and cause open grain or shrinks. Blend into casting by tapering or flattening the fillets. Bosses should not be included in casting design when support for bolts can be obtained by milling or countersinking.

Thickness of bosses and pads should preferably be less than the thickness of the casting section they adjoin, but thick enough to permit machining without touching the casting wall. Where the casting section is light and does not permit use of this rule, then the following minimum recommended heights can serve as a guide:

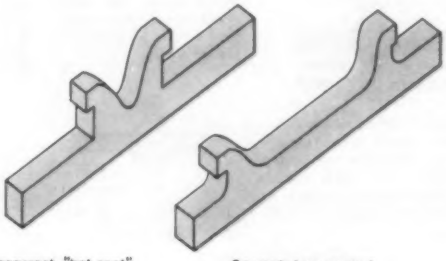
Approximate Casting Length, ft	Height of Boss, in
Up to 1½	0.25
1½-6	0.75
Over 6	1.0



When there are several lugs and bosses on one surface they should be joined if possible, to facilitate machining. A panel of uniform thickness instead of many pads of varying height simplifies machining.

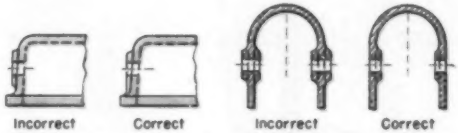


Continuous rib instead of a series of bosses permits shifting hole location.



Incorrect—"hot spot" at center.

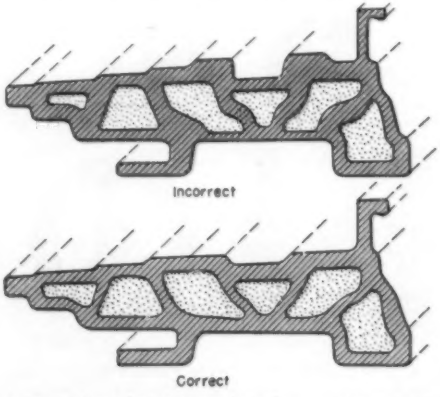
Correct—lugs spread out promotes uniform solidification.



Undercuts should be eliminated wherever possible.

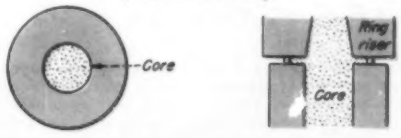
Omit outside bosses to obtain straight draft.

RULE 8 — Proportion Dimensions of Inner Walls Correctly

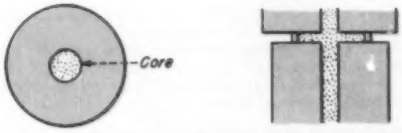


Inner sections of castings resulting from complex cores cool much slower than outer sections, therefore reduce inner sections to 0.7 to 0.9 of the outer wall, depending on intricacy and shape of design. Avoid sharp angles.

Cylinders and Bushings



When diameter of core equals thickness of casting, danger point of casting soundness and risering is being reached and core begins to slow cooling of center—making feeding difficult unless chillers are used in core.



When diameter of core is one-third of casting section or less, feeding is difficult if ordinary sand is used. Steel tube core filled with lead or sand, or a graphite, steel or cast iron rod is preferred. In such bushings, do not use cores, and cast solid.

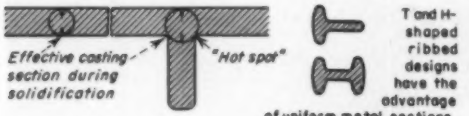
RULE 9 — Design Ribs and Brackets for Maximum Effectiveness

Ribs have two functions: (a) To improve stiffness; and (b) to reduce weight. Correct rib depth and spacing depends on the overall engineering design.

Stiffness of structures may be improved by selection of type of cast metal used. A plate or wall in an iron with high modulus of elasticity may not require to be ribbed, but ribbing would be necessary with a lower modulus material.

Ribs and brackets can create molding problems, "shrinks" and local casting weakness if incorrectly designed and applied. If too shallow in depth or too widely spaced, they are ineffectual.

Thickness of Ribs. Uniformity of casting section and freedom from "hot spots" is essential. Ribs tend to increase metal section.



T and H-shaped ribbed designs have the advantage of uniform metal sections, hence uniform cooling.

Incorrect - thin ribs should be avoided when joined to a heavy section; they lead to high stresses and cracking

Incorrect - local accumulation of metal at junction between ribs and main casting should be prevented.

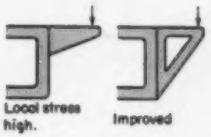
Correct - ribs should solidify before the casting section they adjoin. Thickness of rib should be 0.8 - 0.9 of casting thickness.

Depth of Ribs. Preference is for ribs having depth appreciably greater than thickness. Ribs in compression offer a greater factor of safety than ribs in tension. However, castings having thin ribs or webs in compression may require design changes to give necessary stiffening to avoid buckling.

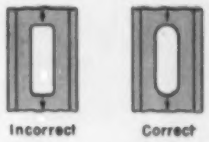
Undesirable

Cross-coupled ribs should preferably be designed as doubled T forms.

Cross ribbing or ribbing on both sides of a casting is undesirable from the foundry viewpoint, increasing casting defectives and total cost to user. Cross ribbing creates local "hot spots," renders feeding solid difficult, causes local weakness and porosity. In flexure, ribbing on both sides of the plate results in inefficient use of metal and local casting weakness. Avoiding complex ribbing simplifies molding procedure and assures more uniform solidification conditions. Casting stresses and stress distribution favor omission of ribbing if the casting wall itself can be made of ample strength and stiffness.



Local stress high. Improved



Incorrect Correct

Brackets. Brackets carrying offset loads introduce bending moments both local and in the body of the casting. Contact with main casting should be as long as possible. Brackets can be detached from the main casting (cast separately) and attached to the main structure. Simplifies molding — reduces cost of manufacture.

Avoid rectangular shaped cored holes in ribs or webs. Use oval shaped cored holes with the longest dimension in the direction of the stresses.

RULE 10 — Allow for Shrinkage and Machine Finish in Dimensional Tolerances

A rule sometimes applied is that dimensional tolerances should be approximately half the maximum shrinkage allowable for the particular type of metal. This rule does not hold in extremely large and complex castings, and in castings made with such accuracy that no machining or finishing outside the foundry is required.

CAST METAL SHRINKAGE ALLOWANCES
(Contraction in. per ft)

Gray Cast Iron	1/10-5/32
White Cast Iron	1/8
Malleable Cast Iron	1/8-5/32
Meehanite Metals	1/8-1/10
Aluminum Alloys	5/32
Magnesium Alloys	5/32
Yellow Brass	5/32-7/16
Gun Metal Bronze	1/8-7/16
Phosphor Bronze	1/8-7/16
Aluminum Bronze	1/8
Manganese Bronze	1/8
Open Hearth Steel	7/16
Electric Steel	1/4
High Manganese Steel	5/16

These figures are to be used with caution because most castings have several different shrinkage allowances according to their size, design complexity, relative mass of core vs metal, varying metal thickness, nature of metal, temperature of pouring and mold material.

Machine Finish Allowance. The allowance for machine finish depends on: (a) Type of metal used; (b) design of the casting; (c) size; (d) tendency to warp; and (e) machining method.

TYPICAL MACHINE FINISH ALLOWANCES
(in addition to shrinkage allowance)

Dimension of Casting, in	Expected Tolerances for "As Cast" Dimension, in.
up to 8	± 1/16
up to 14	± 3/32
up to 18	± 1/8
up to 24	± 5/32
up to 30	± 3/16
up to 36	± 1/4

Machining allowances for cylinder bores are difficult to specify in a general way. Often a plain cylinder, such as is cast for piston ring stock or for a cylinder liner, will contract a normal amount lengthwise but there may be no contraction in the inside bore. The accompanying allowances are given as a guide.

ALLOWANCES FOR MACHINING CYLINDERS OF SINGLE BORE

Diameter, in.	Allowances, in.
4	0.12-0.2
4-8	0.12-0.24
8-12	0.2 -0.32
12-20	0.25-0.40

CYLINDERS OF MORE THAN ONE BORE

Diameter, in.	Allowance on Wall Thickness, in.
8	0.16-0.24
8-12	0.2 -0.28
12-20	0.24-0.32
20-32	0.24-0.40
32-48	0.32-0.47
48-71	0.40-0.55
71-102	0.4 -0.65
102-150	0.55-0.65
150-215	0.7 -0.8
over 215	0.8 -0.9

Casting section dimensions should not be reduced by drilled holes or machining. An inserted stud cannot restore the effectiveness of the original metal sections; therefore, the wall section adjacent to drilled holes should be equivalent to the main body of the casting.

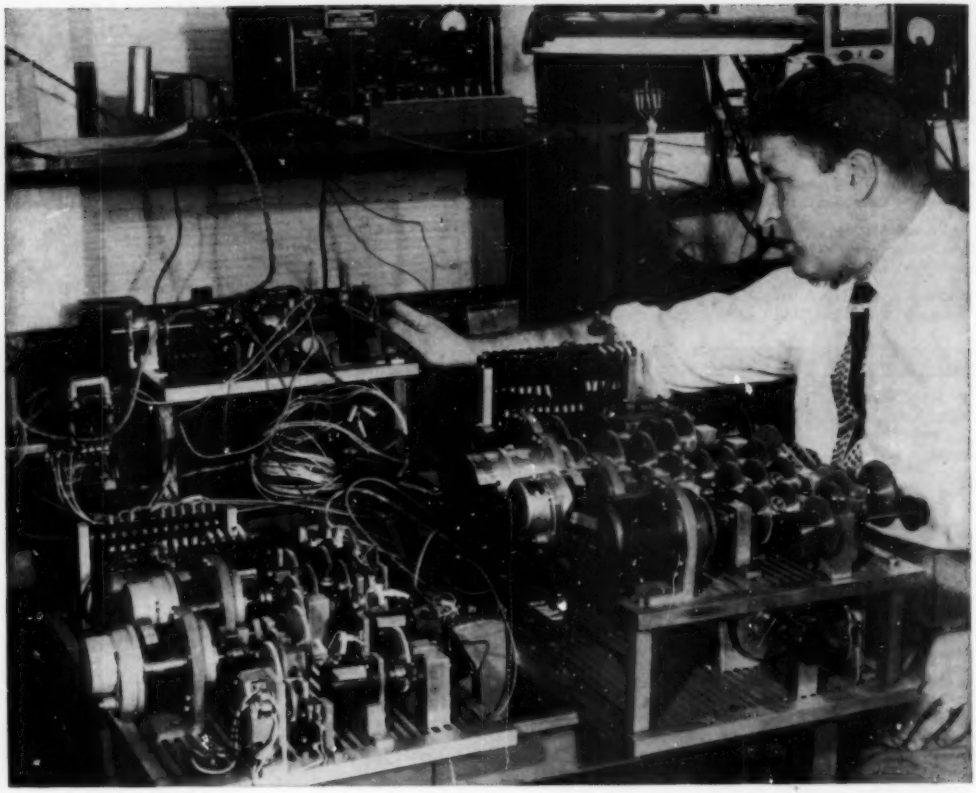


Fig. 1—Testing an experimental servomechanism assembly built from standardized parts. Precise modifications can be made quickly.

Standardized Parts Speed Servomechanism Development

A versatile, time-saving method of setting up working models for the experimental testing and development of control instruments and computer mechanisms.

J. G. CUNNINGHAM
Reeves Instrument Company

WHILE MOST HIGHLY PRECISE automatic control systems are basically electronic, high precision mechanical assemblies are often required for conversion of electronic signals into mechanical movements.

Designing the mechanical part of the system involves consideration of large numbers of alternative components. Different gear ratios between rotating components are tried to get a good balance between inertia and speed of response. Also, different values of friction, inertia and backlash in the system are examined to determine the best possible design. Furthermore, a potentiometer may be combined with a gear train to vary the amplification somewhere in the system.

Test methods are generally preferred for the consideration of these alternatives because the number of elements in the system usually is so large that analytical treatment becomes difficult. Also, nonlinearities frequently result in either additional complications in the analytical treatment or a reduced reliability in the results.

For these reasons, this study is usually made by testing a model of the system. The model may be precisely engineered, but more often a collec-

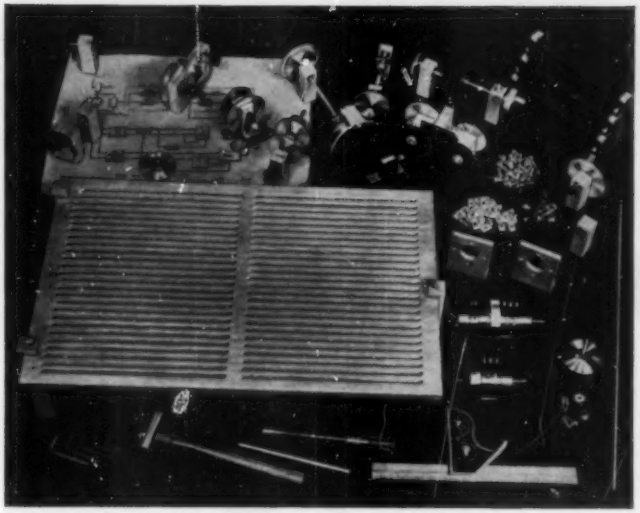


Fig. 2—Schematic diagram of a typical assembly and the tools and component parts necessary for its construction.

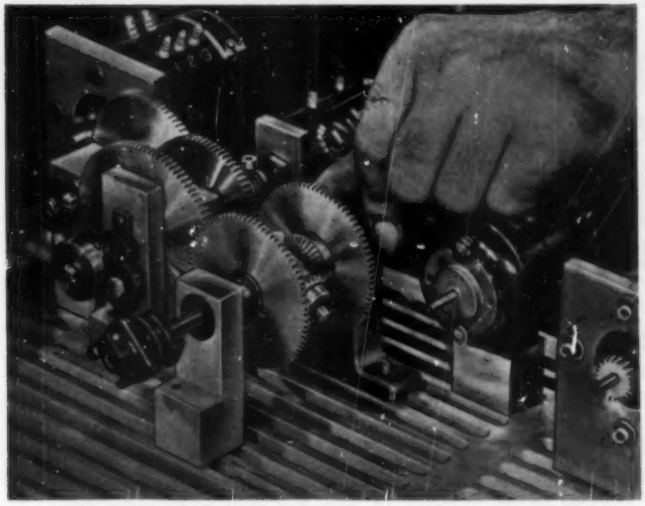


Fig. 3—The assembly of standardized components on a base plate.

tion of the necessary gears, motors, cams, linkages and other elements is assembled and mounted on a base in the most expedient manner. These development arrangements are often known as "breadboard" models.

Test programs can be greatly simplified by the use of a properly developed prefabricated breadboard system. Without such a system, the initial design and assembly of the experimental model and its subsequent modification during test are frequently the source of considerable error, delay and irritation. The component parts, since they must be precision custom made, are always costly. Furthermore, most electronic laboratories and small instrumentation laboratories are not equipped to make them and hence delivery dates and workmanship are difficult to control. The use of a properly developed prefabricated breadboard system consisting of standardized parts can materially reduce these difficulties.

Such a prefabricated breadboard system should be organized around a rigid base plate on which the other parts can be mounted. Hangers to mount commercially available rotating components, such as motors, synchros, potentiometers and resolvers must be included. In addition, standardized linkages and gear trains for connecting these components are required. Finally, the components of a prefabricated breadboard system should be so constructed that the following requirements can be satisfied:

(1) Parts must be interchangeable. Dimensions must be standardized to minimize the number of different parts required.

(2) Means of adjustment must be sufficient for adequate mechanical alignment.

(3) Parts must be made with a high degree of precision.

(4) Assembly of components with simple tools must be possible. Special designing of parts, as well as machine shop work, should be practically eliminated.

A prefabricated breadboard mechanism system that accomplished these objectives is now commercially available. A typical set-up in operation is shown in Fig. 1. In Fig. 2 is shown a schematic diagram and a typical system together with the tools and components required to build it. The breadboard consists basically of a slotted aluminum base plate with an accurately machined flat surface and squared edges. The hangers can be mounted loosely in their approximate position on the slotted plate and secured by screws. Special "T" washers add rigidity.

All shafts are $\frac{1}{4}$ in. in diameter to receive the standard couplings and gears. Shaft hangers have standard ball bearings for receiving the $\frac{1}{4}$ in. shaft and are made with a standard distance of $2\frac{1}{2}$ in. from shaft center to base plates. Double bearing hangers support the ends of long shafts.

Gears are selected from stock to give desired ratios. Small pinion gears are made of stainless steel. Larger gears, however, are made of aluminum to reduce inertia. They are secured to the shafts by small clamps.

Other standard parts consist of differential units high and low speed dial assemblies for checking performance of the system, adjustable mechanical limit stops to protect components, and a quick acting magnetic clutch for automatically cutting sections of the gear train in and out as required. A group of components, Fig. 3, is shown being assembled on a breadboard.

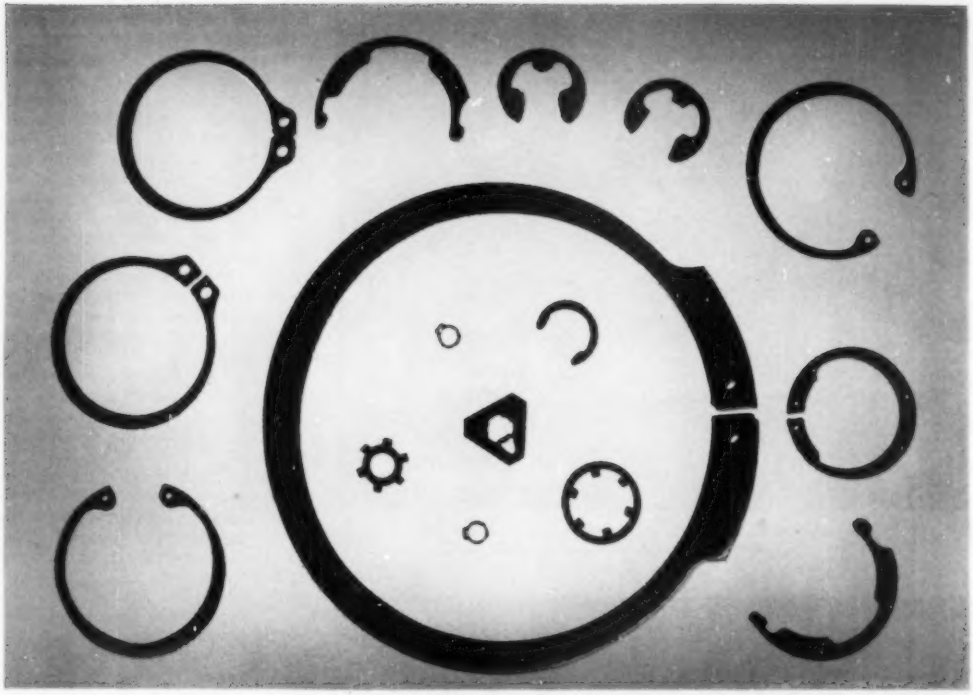


Fig. 1—Stamped metal retaining rings of different types and sizes. Sizes range from ¼ to 10 in. for standard rings; types depend on application requirements, such as rotational speed, axial take-up, shaft accessibility, and the ease of installation and removal.

Which Stamped Retaining Ring?

Construction and application of basic kinds of retaining rings. Width and depth of grooves required, thrust limitations, and amount of end play that can be taken up.

HENRICH HEINMANN
Walden-Kohinoor, Inc.

AMONG THE EXISTING METHODS of fastening and/or locating machine parts or components in an assembly, retaining rings or snap rings have a unique advantage: They can be snapped into any properly designed circumferential groove to form an artificial shoulder. Being hard-tempered springs, their shearing strength—and therefore their thrust and impact capacity—is high. Consequently, they can be used to replace nuts, machined or pressed shoulders, collars, cotter pins, or other positioning or thrust devices, often with one or more of the following results:

1. Quicker assembly and disassembly of component parts. (Accurate positioning of the components relative to the groove without danger of marring the surface.)
2. Reduced machining and grinding operations. (Substitution of centerless grinding for machining and plunge grinding and elimination of threading, tapping, and drilling operations.)
3. Simplification of design. (Reduction in the number or complexity of parts in an assembly.)
4. Reduced size. (Thin rings replacing heavier nuts and shoulders.)
5. Elimination of looseness or end play resulting from accumulated tolerances, or from wear in service.

Basic Types of Retaining Rings

There are two basic types of retaining rings: One, a bent wire ring of uniform cross section; the other, a tapered circular ring that is stamped from strip or sheet stock. The former is more economical to make since only a small amount of scrap is produced by the cutting and forming operation. If properly selected, the thrust and impact capacity of these rings usually is satisfactory because the shear strength of the material is relatively high and

the ring thickness may be chosen according to requirements. In any case, the thrust and impact capacity of the ring exceeds that of the groove, which is usually cut in cold-rolled steel, cast iron, or bronze. However, an analysis of the working stresses occurring in spreading or contracting a wire ring shows that it may take a permanent set unless it is carefully dimensioned and handled. Radial thickness or section height for a given degree of spreading or contracting has to be comparatively small so that the working stress in the ring does not exceed the yield strength of the material of which it is made. That means that either a shallow groove is required when a large protruding shoulder is necessary, or that a smaller shoulder must be used when a deeper groove is imperative.

The main features of stamped metal rings, Fig. 1, are a tapered radial width, symmetrically decreasing from the middle section to the free ends of the ring; and apertured lugs at the end for ease of application. The eccentricity of the inner and outer circular edge of this type of rings—external rings for shafts and internal rings for shafts and internal rings for housings—govern the deformation of rings under spreading or contracting forces. These rings stay circular under deformation as long as the working stresses do not materially exceed the yield strength of the spring material. As each ring portion is subjected to the same degree of deformation, the largest possible spread or contraction is reached with the smallest possible working stress. That means that for a given maximum section width—determined by the necessary shoulder height to abut a machine part effectively—the maximum degree of spreading or contracting, as expressed in a percentage of change in ring diameter, is approximately 10 percent of the free ring diameter in accordance with standards NAS 50 and 51, set up for the aviation industry by the National Aircraft Standards Committee. It is obvious that, owing to such a relatively large degree of spreading or contracting, the rings can be used even with relatively large variations in shaft and housing as well as in groove diameter.

As far as the static thrust acting on the ring assembly is concerned, not only the strength of the ring itself but also the strength of the seating groove has to be taken into consideration. The maximum static thrust the assembly can take is determined by whichever is weaker—the grooves or the ring. If the groove is cut in relatively soft material such as cold-rolled steel, brass, or aluminum, the groove is weaker than the hardened ring. The compressive strength of the soft material is much less than the shearing strength of the hardened ring (a ratio at least 1 : 2). Also, the standard groove depth and thus the height of the groove wall is less than the ring thickness. Therefore, for high static thrusts the shaft or housing generally should be through-hardened or case-hardened to increase the strength of the groove wall to approximately that of the hardened ring.

The ultimate shear strength of materials commonly used for stamping rings is given in Table I. It is easy to compare the thrust capacity of both ring and groove with the ultimate load the ring assembly is exposed to in service and to find out whether the assembly is strong enough or if an increase in ring thickness, groove depth and/or groove hardness is advisable.

What is true of thrust loads is also generally true of impact loads. Test results have shown that the maximum impact a ring can withstand—in inch pounds—is equal to one-half the maximum thrust capacity of the ring multiplied by the ring thickness, or

$$P_i = \frac{Pt}{2}$$

This formula, which can also be derived mathematically, is accurate within an approximate hardness range of 42 to 54 Rockwell *C*. Under similar considerations, it has been found that the maximum impact the groove can take equals $Pd/2$, wherein P is the maximum thrust that the groove wall can withstand and d is the groove depth. While a ring under the maximum impact according to the formula $Pt/2$ breaks through, the groove wall under the maximum impact $Pd/2$ is entirely deformed and flares out conically. In the first instance, i.e., when the impact strength of the ring does not exceed the impact strength of the groove, the ring does not lose its seat in the groove but breaks; while in the second instance—the impact strength of the groove being less than the impact strength of the ring—the ring will, on account of the conical deformation of the groove wall, slide over the groove wall and jump off. To be on the safe side, the permissible impact on ring or groove should not exceed one quarter of the maximum impact load that the ring or the groove, respectively, can take. With this safety factor, it is certain that the impact stresses on the ring or the groove wall will not exceed the allowable limit for working stresses.

Basic Types of Stamped Rings

Stamped rings are made in several different types, each of which has certain advantages and limitations. The standard type is similar to those shown at (A) and (B), Fig. 2.

These units are suitable for most general applications and are available in sizes ranging from $\frac{1}{8}$ to 10 in. for shafts and from $\frac{1}{4}$ to 10 in. for housings. A fair idea of the number of available sizes can be gathered from the fact that there are approximately 30 standard diameters listed between $\frac{1}{8}$ and 1.0 inch. Rings of the standard type up to 18 in. also can be and have been manufactured.

There are cases in which the nonuniformly protruding shoulder of the standard ring is objectionable, for instance, if machine parts with large chamfers or corner radii or with curved end surfaces have to be abutted. For such assemblies, the so-called "inverted" ring (C) and (D), Fig. 2 has been developed. The taper of this ring is reversed, that is, it does not lie at the side of the protruding ring shoulder but at the side of the groove, resulting in a uniformly protruding ring shoulder all around the ring circumference which is high enough to abut satisfactorily machined parts with large chamfers or corner radii. This type of external and internal ring is available

Table I—Mechanical Properties of Materials For Stamped Retaining Rings

Material	Rockwell Hardness	Ultimate Tensile Strength, psi	Yield Strength, psi	Shear Strength, psi
Steel (SAE 1065–1090)[1]	C (48–56)	238,000–280,000	180,000–210,000	150,000
Beryllium copper	C (38–40)	190,000–200,000	145,000–150,000	110,000
Aluminum R 303	B (85–87)	75,000	65,000	45,000
Alclad 75 S-T	B (85–95)	75,000	62,000–67,000	46,000
Phosphor-bronze (Grade D)	B (100–105)	120,000–133,000	90,000–100,000	75,000
Stainless Steel	C (48–50)	240,000–250,000	180,000	130,000

[1]Standard material

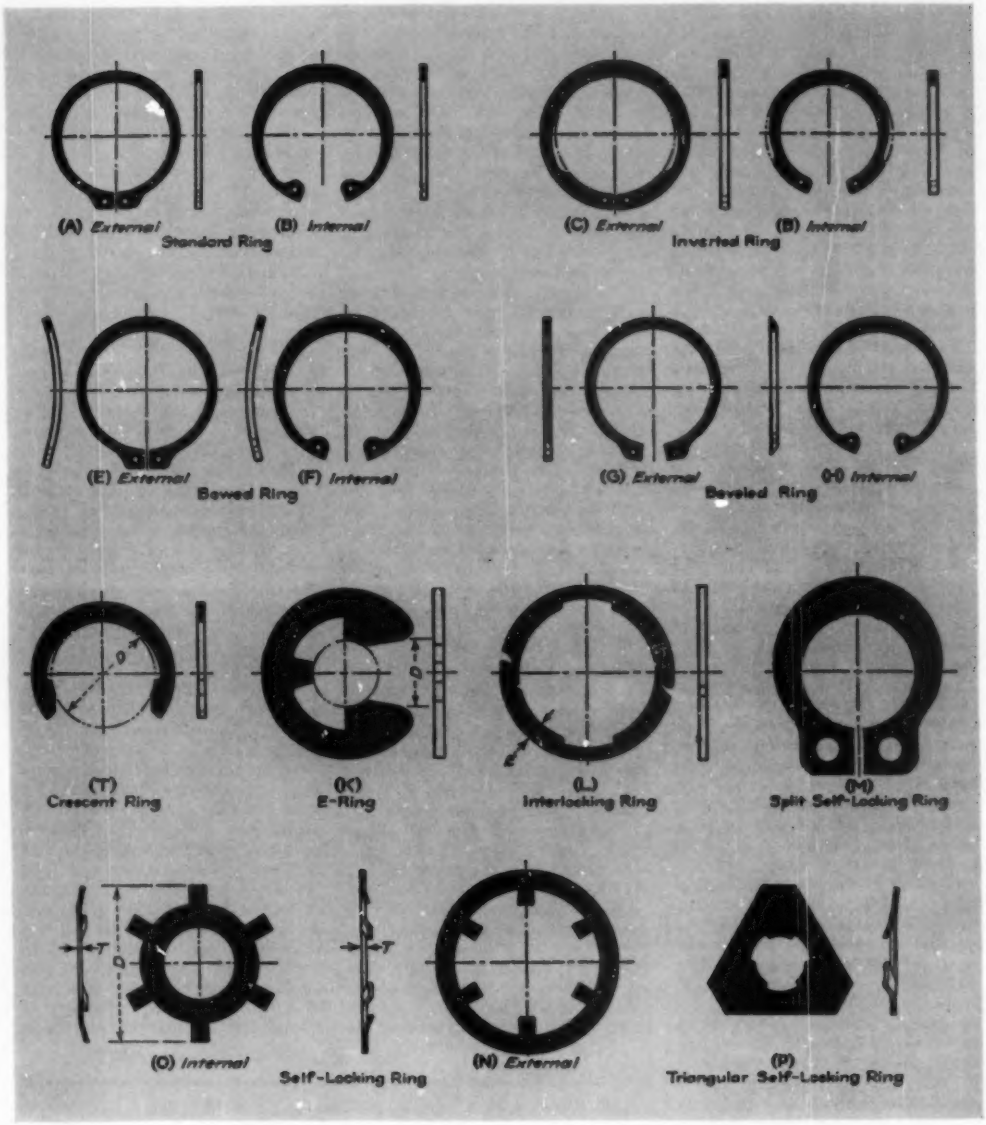


Fig. 2—Fifteen common types of retaining rings: (*A*) Standard external ring for shafts; (*B*) standard internal ring for housings; (*C*) inverted external ring; (*D*) inverted external ring; (*E*) bowed external ring to take up end play resiliently; (*F*) bowed internal ring; (*G*) beveled external ring to take up end play rigidly; (*H*) beveled internal ring; (*T*) crescent ring; (*K*) E-ring; (*L*) interlocking ring; (*N*) self-locking external ring; (*O*) self-locking internal ring; (*P*) triangular self-locking ring; (*M*) split self-locking ring to resist thrust in two directions. Other special types also are available.

for shaft sizes up to 4 in. in diameter only, since the minimum shoulder height of the standard ring is sufficiently high in larger sizes. The ultimate thrust capacity of these rings, due to the diminishing arc length of the abutting groove wall, is approximately $\frac{3}{4}$ that of the standard ring. The groove depth, as with standard rings, should approximate 2 to 2.5 percent of the shaft or housing diameter.

It is obvious that deviations in ring thickness, over-all length of the abutting machine part, and location of the groove may add up to some clearance between the abutting surface of the ring and the corresponding machine part to be located. To overcome this end play or clearance between ring and machine parts, two special modifications of the standard stamped rings

have been developed. The first type is the so-called bowed ring which is bent out of its plane around its horizontal center line. The bowed ring acts in an axial direction as a floating spring, but without losing its tight grip against the bottom of the groove in radial direction. For relatively small assemblies involving shaft or housing sizes not over 1.5 in., this bowed ring is an effective means for taking up end play resiliently and for damping vibrations and oscillations. This modification is shown in sketches (E) and (F), Fig. 2; Fig. 3 shows the increasing force required to flatten an external bowed ring for a shaft of 1¼ in., the ring having an initial bow of 0.030 inch. Obviously, the groove width for bowed rings has to be larger than the groove width for standard rings by an amount equal to the height of the bow.

Another modification of the stamped ring used to minimize the problem of end play is the so-called beveled ring as shown in sketches (G) and (H), Fig. 2. The groove-engaging edge of this ring is tapered or beveled under a small angle (about 15 deg) and abuts against an outer groove wall that is tapered at the same angle. With a load on the ring, the tapered edge acts like a wedge so that the ring, expanding or contracting more deeply into the groove, is shifted to a certain degree in the axial direction until it abuts against the machine part, thus bridging end play rigidly. The angle of the wedge-like edge being smaller than the angle of repose, the ring is locked in its end position against axial thrusts exerted by the machine part, Fig. 4. It thus is obvious that this ring takes up the end play rigidly.

When a shaft is axially inaccessible, none of the aforementioned rings can be positioned in its groove. For such constructions, open rings that may be snapped in place across the shaft directly in the plane of the groove are required. Two types of such rings have been developed. A so-called "crescent" ring is shown at (T) in Fig. 2; this is an open ring the section width of which diminishes according to the same rules as set forth for the standard ring. The taper of the ring results in two favorable properties: First, due to its circular deformation, the ring always maintains a tight fit against the bottom of the groove; second, the length of the free legs is increased correspondingly. The taper of this ring is directed against the bottom of the groove so that there is a uniform shoulder all around its encircling length. The section width of this modification is obviously subject to certain limitations depending on the working stresses the ring is exposed to when being snapped into place. The working stresses should in no case exceed the yield strength of the material to avoid a permanent set and a loosening of the ring in the groove—especially dangerous in the case of open rings.

A second type of open ring which is free of the limitations of the crescent type is the E-ring illustrated in Fig. 2 (K). This ring is provided with three inwardly protruding prongs, spaced approximately 120 deg apart, that abut the bottom of the groove. The radius of the bending arms is considerably larger than the radius of the groove so that a relatively deep groove may be provided and a high protruding shoulder obtained. This E-ring is also available as a bowed ring to take up end play resiliently between the ring and the machine part to be located.

Open rings are not recommended on shafts rotating at high speed because the centrifugal forces acting on them may exceed their clamping power and the rings may jump off the groove. When the speed of the shaft is higher than this limit, a two-part interlocking ring such as shown at (L) in Fig. 2, may be used. This ring is locked in position by engaging hooks on the two parts and the shear resistance of these hooks is sufficiently high that the ring is secure under practically any rotational speed encountered. It is obvious that the depth of its groove is independent of the shaft diameter since the ring halves are assembled in the plane of the groove across the shaft. Also, the section height of the ring and, therefore, its abutting shoulder may be relatively high because of the small degree of spreading the ring halves are subjected to in assembly and because of the space in the middle part of the ring halves.

All the rings so far discussed require a groove in the shaft or housing. But it is not always possible or advisable to groove a shaft or a housing in such small devices as instruments or small business machines. Usually in such assemblies the shoulder need not absorb considerable thrust but rather must serve merely as a holding device against small vibrations or impacts. A ring has been developed that has enough holding power in one direction and may be slipped over the shaft or into the housing in the opposite direction exactly to the desired place, i.e., against the face of the machine part to be held in place; internal and external types are illustrated at (O) and (N).

Characteristic for both external and internal types of this closed—not split—ring are inwardly or outwardly protruding, slightly inclined prongs that abut against the outer surface of the shaft or the inner surface of the housing and which, due to their inclination, allow assembly in one direction in which their inclination tends to increase, but develop holding power in the opposite direction where the inclination of the tongues tends to decrease.

A further type of external self-locking retainer that can be assembled on a shaft or pin without grooving is the so-called "triangular ring", (P) Fig. 2. Three slightly inclined prongs, spaced at 120 deg, protrude from the triangular ring body. The side portions connecting the prongs may be slightly bent out of their plane. Functionally characteristic for this type of

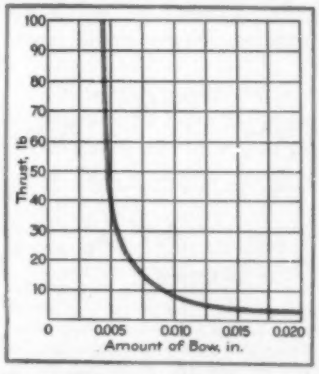


Fig. 3—Thrust required to flatten 0.030 in. bowed retaining ring of 1¼ in. shaft diameter. The amount of bow can be varied somewhat for rings of the same diameter.

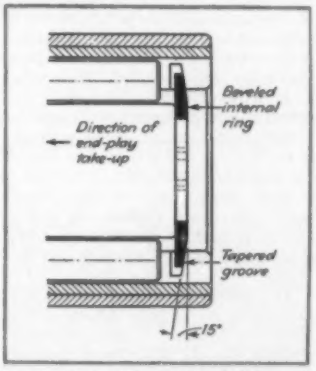


Fig. 4—Application of a beveled internal ring. Such rings are often used to take-up end play rigidly on shafts or housings over 1¼ in. For smaller shafts, a bowed ring is recommended.

ring is its high thrust and impact capacity and the considerable variations (tolerances) in shaft size it permits.

The self-locking rings discussed above and provided with a closed ring body act as self-locking retainers in one direction only. But there is also a need for a ring assembled on a straight non-grooved shaft or in a straight non-grooved housing which locks in both directions. For this special purpose, a split ring has been developed that may be assembled with pliers like a standard ring. This split ring shown at M, is so dimensioned that it exerts a pressure against the surface of shaft or housing high enough to produce, in both directions, friction forces that withstand moderate thrust loads or impacts. The simplicity of this ring and of the way in which it is handled makes it a successful substitute for small collars which are frequently employed as locating means in light machinery, business machines, instruments and the like.

The previous description of standardized types of stamped rings is by no means exhaustive. For the solution of special problems submitted by the industry, special rings that deviate from the standard types in both form and function have been developed. But for the main problems encountered in practice, these standard types are sufficient and satisfactory.

Studies in Fundamentals of Plasticity to Aid Design

D. C. DRUCKER
Brown University

ONE OF THE MAIN OBJECTIVES in the field of applied mechanics today is the development of a sound and practical mathematical theory of plasticity that will permit computation of stress and strain and permit the building of valid intuitive concepts of how stressed bodies behave after their limit of elasticity is reached at some or all points. Problems of stress-concentration, of fatigue, in fact the actual behavior of most structural and machine parts cannot be clearly understood until the basic concepts are evolved and a number of solutions obtained.

The Office of Naval Research and the Bureau of Ships are sponsoring a study at Brown University and have set as the first problem the collection and analysis of physical facts and also the hypotheses to explain them.

Under the direction of Professor William Prager, literature has been searched for experimental knowledge of how materials behave in the plastic range. In addition, the existing mathematical theories of plasticity have been systematized and extended. New solutions to problems of practical and theoretical importance are being obtained on the basis of known methods when it is felt that they will be useful for the over-all program.

Brief descriptions of the major topics now being studied will give a clearer picture of the type of work being done and its value to the designer.

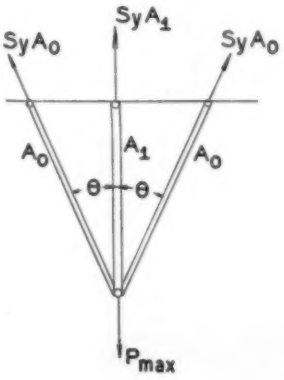
The problems of limit design and shakedown are of great interest to the Structural Group. A proof has been obtained for the limit design theorem popularized in this country by Professor Van den Broek. An ideally ductile (no work hardening) structure or machine will not fail (in the sense of unlimited yielding) if there is any system of internal stresses below yield values that will maintain the applied forces in equilibrium.

Stress design on the basis of plasticity is often far easier than the customary elastic procedure. The well-known case of three tension bars supporting a load P serves as a simple illustration. There is no need to solve this statically indeterminate problem as shown in the sketch. The limit load can be obtained directly from the equation

$$P_{max} = S_y A_1 + 2 S_y A_o \cos\theta$$

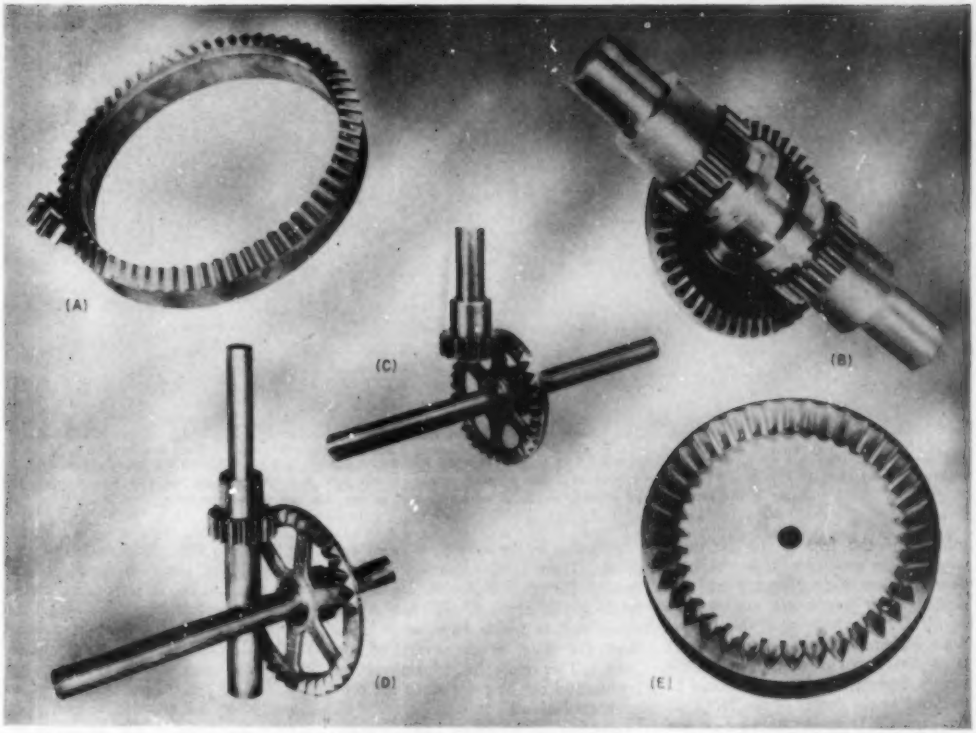
where S_y is the yield stress of the material (work hardening assumed to be absent), A_1 and A_o the cross-sectional area of the bars. As must be expected, the reduction of complicated problems to static determinacy entails a sacrifice. However, the deformation of the structure does not have to be taken into account explicitly and therefore is generally not calculated.

Shakedown is somewhat more complicated but of considerable practical importance. Suppose a shaft is subjected to bending, twisting and axial pull. The range of each load separately is known but each varies independently of the other. The shaft could easily be designed so that, under the worst combination, it would have the desired factor of safety against yielding. Slight initial yielding will do no harm, but repeated yielding will cause trouble. If the part "shakes down"; ie, no longer yields as the loads are applied in their independent random way, the designer would be satisfied. Residual stresses would be present at zero load, but they usually have no ill effect. The principle that applies here is essentially the same as for limit design.



Entirely different questions are handled by the Dynamics Group that is now studying impact problems and metal cutting from the plasticity point of view. For example, the value and interpretation of impact testing after all these years of use if often not clear. Here, as in most cases, basic analytical work is definitely required. Also, much remains to be learned about the process of metal removal, the formation of a built-up edge and the effect of change of rake angle.

The difficulty in obtaining data about the plastic range is basic and requires exhaustive study of the fundamental relation between stress and strain. Some of the many questions that must be answered are: (1) after yielding and plastic deformation has taken place, what criterion governs further plastic flow. Shear-strain energy, octahedral shearing stress or maximum shearing stress may be completely satisfactory for standard design, but they seldom will help the stress analyst measuring strain on the outside of a bar that is pulled and then twisted; (2) how is the stress-strain relation tied to the criterion for further plastic deformation; (3) how can repeated and reversed loading be handled; and (4) how important are time effects?



SOME BASIC types of tapered gears: (A), tapered gear and spur gear that mesh at a low shaft angle; (B), and (C), tapered (face) gears having 90 deg shaft angles; (D), offset face gear and pinion; and (E) internal tapered gear shown without pinion.

Effect of Axis Angle On Tapered Gear Design

GEORGE SANBORN
Chief Field Engineer

BEN BLOOMFIELD
Engineering Department
Fellows Gear Shaper Company

Relationships between the axis angle of tapered gear combinations and the amount of involute action, the face width of the tapered member, and the amount of offset of those members having axis that are non-intersecting.

A TAPERED GEAR differs from a conventional bevel gear in that it may mesh either with a tapered or cylindrical pinion. The axis of the gear and mating pinion may or may not intersect, and the taper angle may be anything up to 90 deg for an external gear, or up to 180 deg for a tapered internal gear. The tooth form may be helical or spur, depending on whether the teeth on the mating pinion are helical or spur. This article will be confined to a discussion of spur tapered gears.

Tapered and face gears having spur teeth, not on a helix, have many advantages. One is that the contact between teeth of mating members does not start across the entire face width of the gear as in conventional spur gears, but rather starts at one edge of the face and gradually creeps across. This is due to the angular relationship of the axes. On designs having a low axis angle, this advantage is not very great, and it is usually desirable to employ helical teeth if noise and smooth running are of prime importance. On high taper angle gears and face gears, the advantage in employing helical teeth becomes less unless quiet running action is important.

When running two tapered gears together, full contact bearings are not theoretically or actually obtained. The bearings are either restricted to the

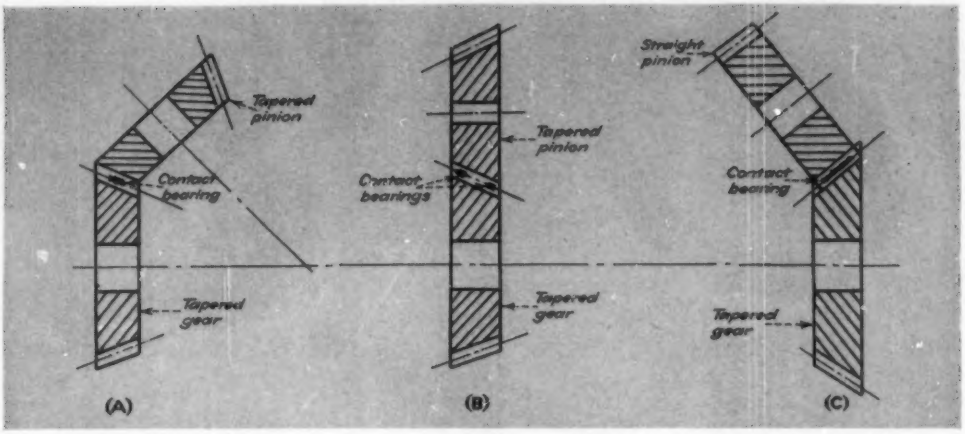


Fig. 1—Contact bearings on tapered gears meshing (A) with a tapered pinion at a low contact angle; (B) end-on-end with a tapered pinion; and (C) with a straight spur gear at a low contact angle. In the first case, the bearing surfaces are confined to center of the teeth; in the second, to the outer faces; and in the last, are across the face.

middle of the face or to the outer edges. For example, if two tapered gears of five inch diameter and ten degree taper angle are cut with a standard three inch gear shaper and run together on properly spaced centers at a shaft angle of approximately twenty degrees, the bearings would be confined to the center of the face. In this case, the large end of taper on one gear would mesh with the large end of the other gear, Fig. 1.

If these same two gears were meshed large end to small end on parallel shafts as shown at *B*, the bearings would be confined to the outer edges of the face. The nature of these bearings can be varied by changing the diameter of the gear shaper cutter employed for cutting. It might be possible to approach a full bearing in this manner, but this undoubtedly would result in an impractical diameter of cutter to be handled.

The most advantageous way of obtaining a full bearing on an angular gear set is to make one member with straight cylindrical elements and put the taper all in the other member, as indicated at *C*. In this case, the straight member is cut like any conventional gear. The tapered member is cut with a gear shaper cutter having the same number of teeth as that in the mating straight member. This gives theoretical full contact between the teeth of the two members.

If it is desired to relieve the bearing slightly at the outer edges of the face, this can be easily accomplished by using a cutter for the tapered member that is made oversize for its number of teeth, or a cutter with a few additional teeth. The amount of departure is governed by the amount of relief desired. There is no formula for determining the amount of thinning of the teeth at the edges of the face when using cutters which have more teeth than the mate, or are oversized, or both. This must be determined by layout, and can be referred to the cutter manufacturer.

Another advantage of tapered gears is that cutting the conventional member requires no special operations or equipment. The tapered member requires some special tooling on the gear shaper, but the cost of the cutting operation itself is comparable to that of cylindrical gears of the same general size and pitch.

Also, the gears are quite easy to assemble. Since one member does not have any taper, it can be positioned anywhere along its axis without changing the bearing between the mating teeth except, if carried to extreme, the two gears would not be in mesh. When mating with external tapered gears, the straight member can be assembled from either side as far as the gear is concerned. The tapered member must be positioned along its axis quite accurately but this applies to one member only. Errors in location of the tapered member will affect the bearings between the teeth; however, this is not particularly sensitive, especially with lower angles of taper.

Finally, tapered gear sets are simple to design, especially those having one straight and one tapered member. The straight member is usually standard in every detail. The diameters of the tapered gear can be calculated in the same way as the diameter of a conventional gear having the same number of teeth and pitch, with this exception: The pitch diameter at the large end can be, as a working maximum, 10 percent larger than the corresponding pitch diameter of a conventional gear, and the pitch diameter at the small end can be, as a working minimum, 5 percent less than the pitch diameter of a conventional gear. A greater difference in the diameters of the two ends usually is found feasible after making a careful check, but the above rule is close enough for a preliminary design of the gears and surrounding parts, such as housings.

This general rule can be expressed in formula form as follows:

$$\text{Large diameter (Approximate)} = \frac{1.1\ N \pm 2\ \text{Cos.}\ \phi}{P} \quad (1)$$

$$\text{Small diameter (Approximate)} = \frac{0.95\ N \pm 2\ \text{Cos.}\ \phi}{P} \quad (2)$$

where N is the number of teeth in the tapered gear, ϕ is the shaft or axis angle between the axes, and P is the theoretical diametral pitch of the pinion. In Eqs (1) and (2), the signs between the terms in the numerator are plus for external gears and minus for internal gears.

The approximate face width of the gear along the angle of taper then is found by dividing the difference in the diameters by twice the sign of the angle, or

$$\text{Face width (Approximate)} = \frac{\text{Large Diameter} - \text{Small Diameter}}{2\ \text{Sin}\ \phi} \quad (3)$$

Limitation on Face Width

The tapered gear has a definite limitation on face width. The teeth of the tapered gear do not have a uniform

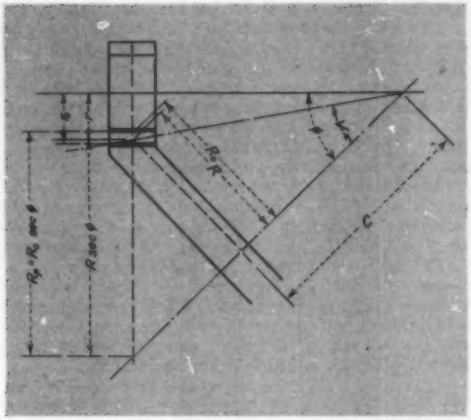


Fig. 2—Dimensional and angular designations: C, cone distance; O, shaft angle; R_o, outside radius of the gear; and r and r_o are the active pitch radius and outside radius of the pinion.

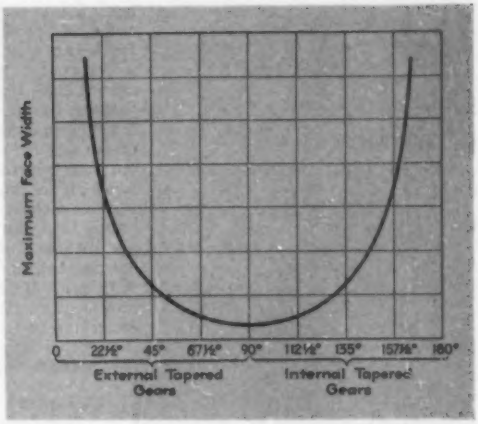


Fig. 3—The greater becomes the angle of taper, the less becomes the maximum face width on the tapered member, as indicated by this graphical presentation of the relationship.

cross-section across the face width, due to the fact that the pressure angle of the teeth vary; they have a low pressure angle at the small end of the taper and a high pressure angle at the large end of the taper. Consequently, an excessively wide face, resulting in a great difference betwen the small and large diameters, will cause the teeth to (1) come to a point near the large end; (2) be undercut severely at the small end; (3) or both. Although a good rule for a preliminary determination of these diameters has been given, it is always advisable to have designs of this kind checked by the tool vendor. The following formulas can be used to determine the pressure angle of the tapered gear and the involute action between the tapered gear and mating cylindrical gear, which will be the pinion, at a given cone distance.

Let ϕ = Shaft angle, or angle between the axes.
V = Pitch cone angle of tapered gear.
K = Gear ratio = $\frac{\text{No. pinion teeth}}{\text{No. gear teeth}}$
r = Active pitch radius of pinion.
R = Active pitch radius of tapered gear.
a = Base radius of pinion
a_t = Nominal base radius of tapered gear.
R_o = Nominal active pitch radius of tapered gear.
C = Cone distance of tapered gear at active pitch point.
C_s = Cone distance of tapered gear at small end.
C_l = Cone distance of tapered gear at large end.
PA = Pressure angle.

Then

$$\tan V = \frac{\sin \phi}{K + \cos \phi} \quad (4)$$

$$R = \frac{r}{K} = C \tan V \quad (5)$$

$$R_o = R \sec \phi \quad (6)$$

$$a = \frac{\text{No. teeth in pinion}}{\text{Theoretical diametral pitch of pinion}} \times \text{Cos (Theoretical } PA \text{ of pinion)}. \quad (7)$$

$$a_t = \frac{a}{K} \sec \phi \quad (8)$$

$$\text{Cos } PA \text{ at small end} = \frac{a\left(1 + \frac{\text{Sec } \phi}{K}\right)}{C_s \tan V \left(K + \text{Sec } \phi\right)} = \frac{a + a_t}{r + R_o} \quad (9)$$

$$\text{Cos } PA \text{ at large end} = \frac{a\left(1 + \frac{\text{Sec } \phi}{K}\right)}{C_l \tan V \left(K + \text{Sec } \phi\right)} \quad (10)$$

To find the amount of involute action for any given cone distance C, indicated in Fig. 2:

Let r_o = Outside radius of the pinion.
R_o = Outside radius of the tapered gear.
R_p = Outside radius of the tapered gear in transverse plane of pinion.
N = Number of teeth on pinion.

Then $R_p = R_o \sec \phi$

$$\text{Involute action} = \frac{\sqrt{r_o^2 - a^2} - \sqrt{R_p^2 - a_t^2} - (r + R_o) \sin PA}{\frac{2\pi a}{n}} \quad (11)$$

or, expressed differently,

$$\text{Involute action} = \frac{\sqrt{r_o^2 - a^2} + \sec \phi \sqrt{R_o^2 - \left(\frac{a}{K}\right)^2}}{\frac{2\pi a/n}{C_s \tan V \left(K + \sec \phi\right) \sin PA}} - \frac{}{\frac{2\pi a/n}{}} \quad (12)$$

It is always advisable to keep the involute action at more than 1.00 for at least half of the face width. For low angles of taper it is quite often possible to have more than an involute action of 1.00 for the entire face width, and even with face gears (90 deg taper angle), the good designer will get an involute action of more than 1.00 for more than half the face width.

Obviously, the greater the angle of

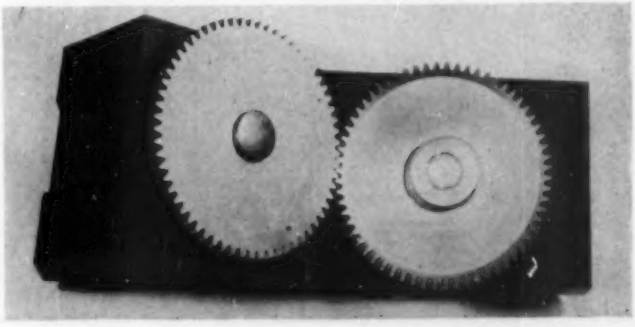


Fig. 4—Tapered gears having a low shaft angle and intersecting shafts.

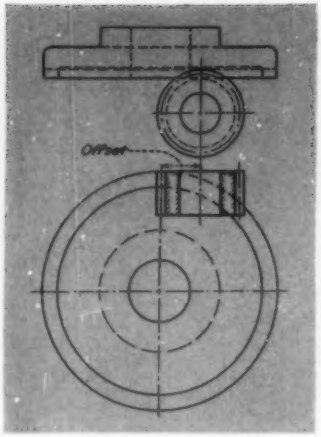


Fig. 5—The permissible amount of offset of tapered gears with non-intersecting axis is limited by the taper angle. For face gears it is about one-fourth of the pitch diameter of the tapered member.

taper the more restricted the face width on the tapered member becomes. For example, for teeth having one degree of taper, the face width could be great before the 10 percent oversize and 5 percent undersize limitations were met. But if the angle of taper were near 90 deg, it would take a relatively narrow face to reach these limitations. This relationship is shown graphically in Fig. 3.

At 0 and 180 deg angles of taper there is no change in pressure angle across the face width of the gear (since the gear is a conventional external or internal gear in these cases) and hence no limitation on face width. The variation in pressure angle across the face width of a tapered internal gear is not exactly the same as that of a tapered external gear, and for that reason, the maximum face widths of internal tapered gears for varying angles of taper is not the same. However, the same general rules apply for establishing the approximate diameter.

If it is necessary to use a face width greater than that possible by tapering one member only, the possibility of tapering both members should be investigated. If the diameters of gears involved are not extreme, a satisfactory contact can be obtained by properly relating cutter diameters. The tool vendor should be consulted in all cases.

Tapered Gears With Non-Intersecting Axis

So far in this article, consideration has been given only to tapered and face gears with intersecting axes. It is equally practicable to make tapered gears that operate with non-intersecting axes. There is a limitation to the amount of offset that can be employed, especially on high angle gears. On a 90 deg gear, as shown in Fig. 5, the maximum practicable offset is approximately one fourth of the pitch diameter of the tapered member. If too great an offset is employed, the teeth of the tapered member are badly mutilated, thus resulting in too great a loss of contact surface.

On low angles of taper the restriction of offset is different. The maximum offset in this case is equal to the sum of the pitch radii. A 90 deg tapered gear combination that is "on center" is shown at *A* in Fig. 6; position *B* shows the maximum "off center" position. At this extreme, the taper effect actually disappears and the teeth of that member which are basically spur, take an appearance of being on a helix, the angle of which is the taper angle when the pinion is in position *A*. Intermediate positions of the pinion result in a combination of taper and apparent helix. If the maximum offset is employed with helical gears and the so called angle of taper is made 90 deg, these gears then become what is known as "hourglass gears."

The approximate large and small diameters of "offset" tapered gears can be calculated in the same way as for "on-center" gears, by merely taking the offset into consideration.

Let N = Number of teeth in tapered gear.
P = Theoretical diametral pitch of pinion.
ϕ = Taper angle.
e = Amount of offset (in.).

Then

$$\text{Large diameter} = \sqrt{\left(\frac{1.1N \pm 2\cos\phi}{P}\right)^2 + e^2} \qquad (13)$$

$$\text{Small diameter} = \sqrt{\left(\frac{0.95N \pm 2\cos\phi}{P}\right)^2 + e^2} \qquad (14)$$

It should be remembered that these diameters are approximate only.

The taper angle to which the gear blank should be turned is less than the shaft angle. This can be calculated as follows:

$$\text{Tangent Blank Angle} = \frac{\text{(Large Diameter—Small Diameter)}}{2 \times \text{face width}} \qquad (15)$$

In taper gear drives it is possible to put the taper in either gear, whichever gives maximum benefit. If the gear ratio is relatively high and the maximum possible face width is desired, the taper should be put into the large member. This permits a greater change in diameter from end to end of the tapered gear for a given percentage of pitch diameter, thereby increasing the face width. Another influencing factor is the cutter; since the cutter for the tapered member must be about the size of the mating gear, one diameter might be practicable for the cutter whereas the other might not. For example, if a pair of gears were to be 5 inches and 10 inches in diameter, it would be better to put the taper on the 10 in. gear and use a 5 in. cutter than it would to put the taper on the 5 in. gear and use a 10 in. cutter.

There might be cases when it would be helpful in gear cutting or in assembling to put the taper in the smaller member. However, this should be avoided except in low taper angles. Face gears (90 deg taper angle) should always be larger than the mating pinions.

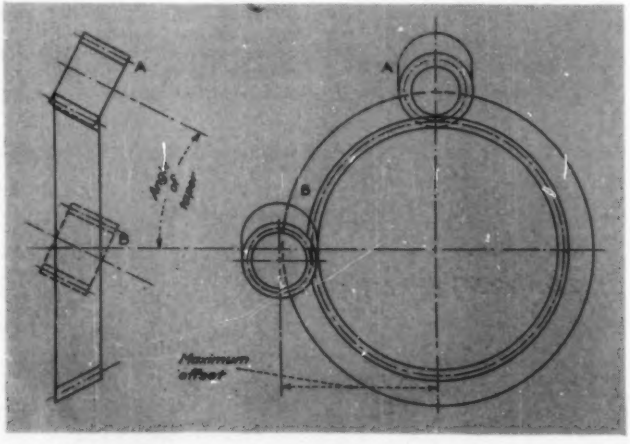
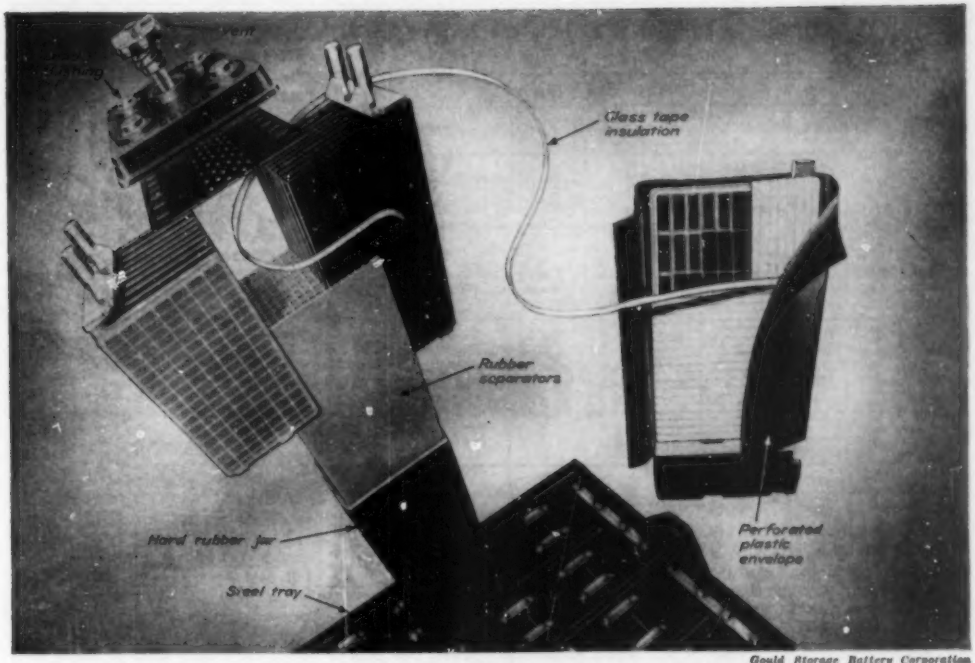


Fig. 6—A low shaft angle tapered gear combination that is at the on-center position (A) and at the maximum off-center position (B).



Gould Storage Battery Corporation

Fig. 1—Exploded view of a Gould lead-acid type battery. Other batteries of this type vary in the details of the construction, but the arrangements are similar. Both of the alkaline batteries use steel containers instead of hard rubber or glass jars.

Fundamentals of Storage Batteries

Operating characteristics of storage batteries and their relationship to equipment requirements. How to avoid application errors and assure customer satisfaction.

UNLIKE ANY OTHER POWER SOURCE, a battery's capacity for continued output decreases with each use, and the remaining capacity at any instant depends upon the rate at which power is drawn. Furthermore, the power continuously or periodically is restored to approximately its original capacity by charging; and the frequency and manner of this recharging affects the life of the battery. These operating characteristics affect battery application.

Types of Batteries

The two principal categories of storage batteries are the lead-acid and alkaline types. There are two alkaline types, namely, the nickel-iron and the nickel-cadmium batteries. Table I gives the basic differences between them. Lead-acid and nickel-iron batteries predominate in this country; the nickel-cadmium battery has been confined almost exclusively to Europe, although domestic manufacture has been announced since the war. Wide use of the nickel-cadmium battery in this country has been hindered because of its high cost, and a shortage of cadmium. But the nickel-cadmium battery does have a long life—15 to 20 years—and this type of battery also performs well at low temperatures.

The alkaline battery is generally claimed to have the following advantages: (1) Greater mechanical strength through the use of steel containers and plate construction, (2) longer life, (3) ability to stand overcharge without damage, (4) ability to stand in a discharged condition without harm, and (5) lighter weight.

The lead-acid battery has the following advantages: (1) Higher electrical efficiency, (2) higher voltage, (3) fewer number of cells for a given voltage, hence less compartment space required, (4) less attention required to keep in good condition, (5) electrolyte need never be changed, (6) higher capacity at high discharge rates and at low operating temperature, and (7) lower initial cost. Fig. 1 illustrates the construction of a typical lead-acid battery; and since about 90 percent of industry's batteries are of this type, the discussion that follows refers largely to the lead-acid battery.

How Batteries Are Rated

Capacity rating of a storage battery is usually expressed in ampere hours. This is the number of ampere hours that the battery will deliver at a speci-

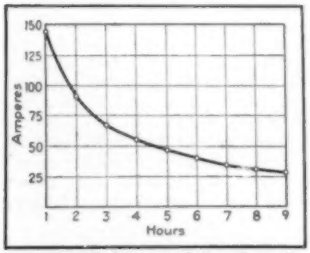
Table I—Characteristics of Lead-Acid, Nickel-Iron, and Nickel-Cadmium Batteries

	Basic Battery Types		
	Lead-Acid	Nickel-Iron	Nickel-Cadmium
Electrolyte	Sulphuric Acid	Potassium Hydroxide	Potassium Hydroxide
Positive Plate Material	Lead Peroxide	Nichelous Hydroxide plus additions of flake nickel	Nichelous Hydroxide plus additions of flake nickel
Negative Plate Material	Spongy Lead	Metallic iron, ferrous oxide, and mercuric oxide mixture	Cadmium or a mixture of cadmium and iron
Case Material	Hard rubber, glass	Steel	Steel
Nominal Voltage	2 volts per cell	1.5 volts per cell	1.5 volts per cell
Ampere-hour ratings of standard batteries (approx. only)	136 to 1,500	900 to 112	60 to 1,024

fied temperature, rate of discharge, and final voltage, when fully charged.

One of the peculiarities of a storage battery is that the capacity is different for each rate of discharge. For a low, or an intermittent rate of discharge, the total ampere hours available are greater than for a high or a continuous rate. This characteristic occurs because the voltage across the terminals drops faster with higher discharge rates, since the electrolyte cannot reach the active material of the plates fast enough to sustain the higher voltage. But at low or intermittent rates of discharge, the acid of the electrolyte has more time to diffuse into pores of the plates, and thus the terminal voltage, for the same number of ampere hours discharged, is higher. To clarify this point, Fig. 2 indicates the hours for complete discharge of a battery at various constant ampere rates.

However, batteries are seldom discharged at a constant rate. Therefore they should be specified to meet the average current requirement over a period of time or, for involved duty cycles, as demanded by the loading.



Gould Storage Battery Corporation

Fig. 2—The storage battery delivers current for a greater length of time when discharged at low rates. The curve shown is for a 13 plate lead-acid cell.

Discharge Characteristics

In matching battery performance with the performance of apparatus to which it furnishes power, two points must be considered: (1) The battery must be able to deliver current at the required amperage rate and at an adequate voltage, and (2) it must be able to deliver this power for a satisfactory length of time.

High rates of discharge are in no way detrimental to lead battery plates. Many batteries operate daily under conditions that require practically all their work to be done at rates that would exhaust a fully charged battery in 10 minutes, if the discharge were continued without interruption. Therefore the designer must keep in mind that the maximum permissible rate of discharge is limited only by the current-carrying ability of the wiring and device to which the battery is connected, or, if this is very high, by the current-carrying capacity of cell terminals and connectors. It is not limited by the plates, because the voltage will drop below a usable value before the active material in the plates is damaged by excessive depletion through the chemical action.

The voltage usually referred to is the "closed circuit" voltage, since this is the value of the voltage when the internal resistance to the load is present. The "open circuit" voltage merely reflects the specific gravity of the electrolyte that is in contact with the plates, hence not the state of charge of the entire cell.

Since the voltage of discharge depends upon (1) rate of discharge and (2) state of charge of the battery, the duty cycle or rates and intervals at which current is drawn also will influence capacity requirements. Discharge characteristic curves, Fig. 3, are required for this analysis.

Because of the acid diffusion effect, when a battery is exhausted at a high discharge rate, the balance of its normal capacity can be obtained at a lower discharge rate or after a period of recuperation on open circuit, at the high discharge rate. In Fig. 4, the results of a test show how all the battery capacity can be obtained by dropping the discharge rate.

For these reasons, the ampere-hour requirements of any battery-powered equipment must allow for size, duration and frequency of peak demands.

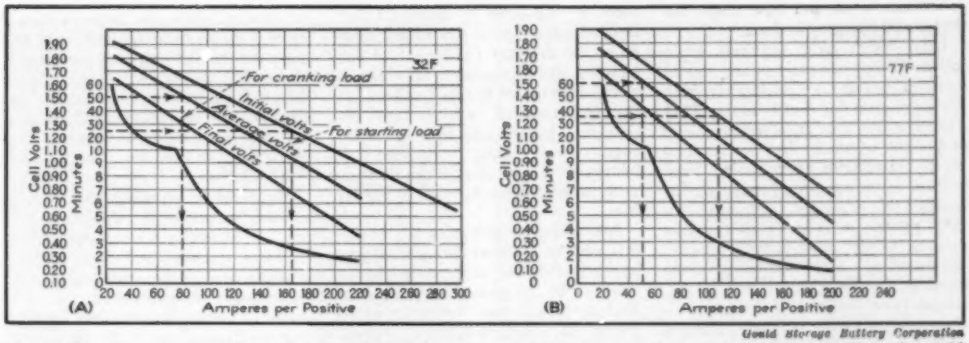
Types of Service

Storage battery applications fall under one of three types of service, depending upon the method of charging: Float service, manually cycled or cycle service, and system governed service.

1. Float service—the battery "floats on the line." It is continuously connected to an a-c supply system. Normally, a small steady flow of current keeps the battery fully or nearly fully charged. Railway signaling circuits, Fig. 5, alarm circuits and emergency switchgear typify this kind of service.

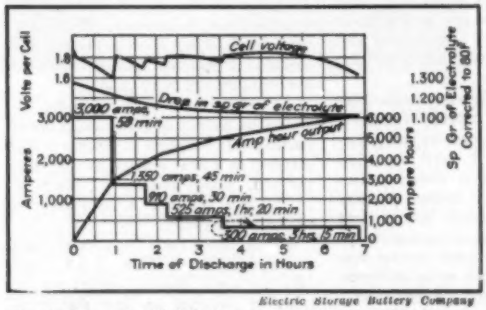
In floating service, the current supply required is the sum of three currents: The small steady or normal load current, a charging current to restore the battery energy lost by discharge for heavy loads, and a small current to provide for self-discharge within the battery. (Small local galvanic cells exist, since 100 percent purity of cell materials is not feasible.)

As the battery is discharged by an emergency, recharging can be done in several ways: (1) Single rate charging, in which the supply system furnishes current at a small fixed value. A variation of this is manually adjusted charging, in which maintenance personnel manually increase the charging rate until approximately near full charge. (2) Two-rate charging is used where relatively heavy intermittent and irregular loads occur; or where frequent power interruptions or unusual variations in the a-c line voltage can be expected. Railroad switch control operations, Fig. 6, often fall in this class. The basic idea is to charge at a high rate until voltage almost reaches the full charge value. Then the control relay automatically returns the charging circuit to a low rate of supply. (3) Taper charging is another method. By a rectifying unit, consisting of a transformer with taps and a rectifying



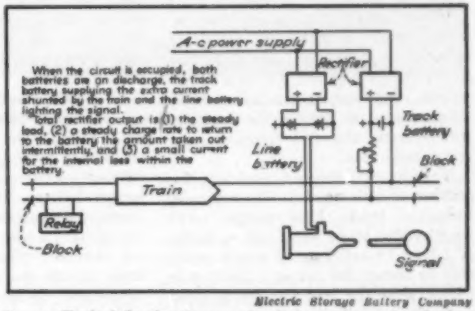
Gould Storage Battery Corporation

Fig. 3—These curves are used to determine the number of battery plates required. (A) This chart is used if operation is contemplated at normal (77 F) temperatures. (B) If the battery is to operate at low temperatures, the 32 F graph would be used because the chemical reaction, hence the capacity, is slower at low temperatures.


Volts per Cell
Cell voltage
Drop in sp gr of electrolyte
3,000 amps, 59 min
Amp hour output
1,550 amps, 45 min
910 amps, 30 min
525 amps, 1 hr 20 min
300 amps, 3 hrs 15 min
Amperes
Ampere Hours
Sp Gr of Electrolyte Corrected to 80°
Time of Discharge in Hours

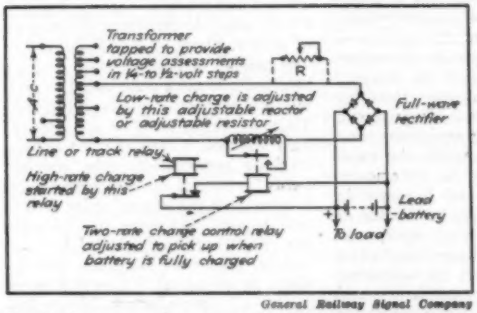
Electric Storage Battery Company

Fig. 4—Effect of acid diffusion on output is shown by the performance of large cell having a 3,000-amp rated capacity for 1 hr. Discharge at that rate nearly exhausted the cell in 58 minutes, but by reductions in rate, all the energy was obtained.


A-c power supply
Rectifier
When the circuit is occupied, both batteries are on discharge, the track battery supplying the extra current shunted by the train and the line battery lighting the signal.
Total rectifier output is (1) the steady load, (2) a steady charge rate to return to the battery the amount taken out intermittently, and (3) a small current for the internal loss within the battery.
Track battery
Line battery
Block
Train
Relay
Block
Signal

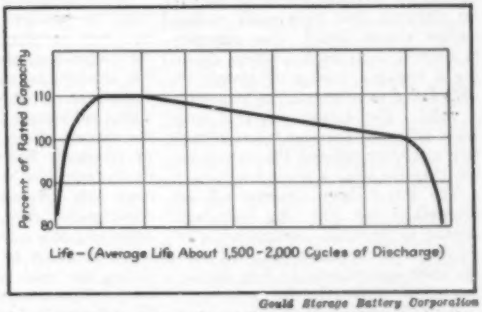
Electric Storage Battery Company

Fig. 5—Typical floating battery circuit for railway signal operation. When there is no train in the block, both batteries are on charge, and the rectifiers supply the steady load taken by the track circuit and signal relays.


Transformer tapped to provide voltage assessments in ¼- to ½-volt steps
R
Low-rate charge is adjusted by this adjustable reactor or adjustable resistor
Full-wave rectifier
Line or track relay
High-rate charge started by this relay
Lead
-battery
To load
Two-rate charge control relay adjusted to pick up when battery is fully charged

General Railway Signal Company

Fig. 6—A two-rate charge control relay for restoring battery capacity quickly. Initial high rate will automatically be reduced.



Gould Storage Battery Corporation

Fig. 7—Capacity curve of a typical lead-acid battery showing how battery performance falls off over the service life.

cell, the supply current is automatically increased after a heavy discharge, then tapers gradually to the normal floating rate as the battery is restored to a full charge condition.

2. Manually-cycled or cycle service systems—these batteries drive electrical equipment until they are discharged substantially. Then the batteries are manually connected to a supply system for several hours until recharged. Charging is stopped, and the batteries are placed in service until the recharging is necessary. Farm lighting service and fork lift truck duty exemplify this type of application.

While the care given to a battery on this kind of duty can greatly affect life, Fig. 7, a battery ought to be good for 1,500-2,000 cycles of discharge.

3. System governed service—these batteries are continuously connected to the electrical equipment and to the electrical supply system. However, they are discharged and charged only at intervals (probably irregular). System-governed service differs from float service in that the state of charge fluctuates between fairly large limits. The schedule and adjustment of the system

determines when and how much discharge and charging is done.

Plate design varies for these applications. Most manually cycled service batteries operate at moderately high discharge rates for 6 or 8 hours. They require many thin cross-section plates to present as much plate surface area to the electrolyte as possible. Float service batteries are generally discharged at relatively high rates for short periods or at low rates for long periods, so they have plates of thicker cross-section. Since system-governed batteries may be subjected to high discharge rates for long periods, and to a wide range in the state of discharge, cycle service type of batteries are usually used.

Selection

When selecting a battery the designer should consider the following factors: (1) Voltage required, (2) ampere-hours required, (3) space limitations, (4) service conditions, (5) temperatures at which the batteries will operate, and (6) unusual operating conditions.

Voltage requirements determine the number of cells needed. For example, industrial trucks have motors rated 24-30 volts, 30-36 volts and so forth. A 12 or 15 cell battery would probably be chosen for use on a 24-30 volt motor, since the lead-acid cell is rated at 2 volts per cell. The designer should not overlook the voltage drop in the leads from the battery to the equipment; nor should he forget the requirements of relays and other electrical elements that must work within narrow voltage limits. For example, in a signal application, a battery showing a terminal voltage of almost 12 volts failed to actuate a relay requiring 8 volts. The answer was that long leads of small diameter between battery and relay reduced the voltage to less than the relay actuating voltage.

The ampere-hour capacity will be determined by (1) the amperage needed to drive the equipment, (2) the hours of operation required and, for some applications, by (3) the nature of the duty cycle.

It also is good practice to have some excess ampere-hour capacity to prevent overdischarging when the equipment is subjected to abnormal duty requirements. One of the poorest economies the designer (or buyer) of battery-powered equipment can make is to use a battery of too low capacity. If the duty imposed requires rapid recharging, battery life will be shortened. Furthermore, operation of battery in a low charge condition is progressively more harmful to battery life.

Manufacturers generally supply several sizes of batteries that will deliver approximately the same ampere-hours. This is to accommodate equipment having various sized battery compartments. It is accomplished by varying both plate dimensions and the number of plates per cell. For example, Table II shows the dimensions of batteries rated at 440 ampere-hours at the 6-hour rate of discharge, as produced by one manufacturer. Low-height, narrow-width or short-length batteries also can be obtained.

Care should be taken to provide adequate ampere-hour capacity for service required. The larger capacity batteries may provide 2 days' operation without recharging. This insures longer battery life, lowers primary power consumption and lessens time out of service for changing and charging batteries. Since cycle service batteries are all operated under different conditions, the battery specifier should consult both equipment and battery manufacturer as to the capacity of the battery required under specific circumstances.

When specifying batteries, it is necessary to consider charging equipment. In a new installation, the capacity of the batteries automatically determines the required capacity of the charging equipment. However, when installing additional battery powered equipment, the existing charging equipment must be reviewed. For example, the existing batteries may be of the 300 ampere-hour size. Because of increases in requirements, they may be capable of delivering only a half day's work, making it necessary to change the battery during the work shift (at additional cost). If new equipment is designed for 600 amp-hr batteries to reduce the time lost in battery changes, the charging equipment may not be of sufficient capacity to handle the larger size batteries. Two solutions are possible: Purchase additional charging equipment of higher capacity, or retain the old charging equipment and double the number of small batteries. Therefore, the designer should be aware of the alternatives he may force on the user by his selection.

Temperature at which the battery operates sometimes is a significant factor. A battery produces current by chemical reaction, and this reaction increases or decreases with corresponding changes in temperature. At full charge, a battery delivers only 65 percent rated capacity at 30 F; 40 percent at 0 F; but delivers 105 percent at 100 F. This occurs primarily because the electrolyte diffuses more readily during discharge at the higher temperature since viscosity is decreased. To circumvent this, a lower specific gravity acid is used—1.260 instead of 1.280 for low temperature applications.

As an example of temperature influence on battery specification, a diesel starting cell required to deliver 1,200 amperes to a final voltage of 0.8 volts per cell, would require 17 plates at 77 F. But at 32 F a 23 plate cell would be necessary.

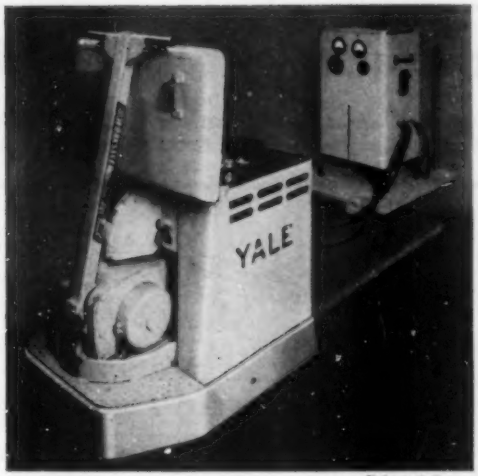
To determine these facts, charts such as those shown in Figs. 3 (A) and (B) are used. Similar curves for all types of batteries are available from manufacturers. From Fig. 3 (A), the current at 77 F corresponding to 1.25 initial volts and 0.8 final volts is 165 amps per positive plate: this figure is divided into the total amperes required (1,260 amp) to determine the number of positive plates (7.3 or 8 positives). The number of positive plates is doubled and one extra plate added to give the total number of plates in the cell. Thus, 17 plates at 77 F are needed. This selection is then checked against cranking requirements (the requirements for turning the engine over until it starts). If the engine under discussion requires 600 amps at 1.50 volts per cell, the battery selected is satisfactory, since from the graph, 600 divided by 80 equals 7.5 or 8 positive plates—a 17 plate battery. Notice that the "initial volts" curve is used when determining breakaway requirements because this is the voltage that a fully charged cell has when the circuit is first closed. The "average volts" curve is used for checking cranking requirements because the voltage will average this value as the discharge continues.

The "final volts" curve indicates the voltage to which the cell can be discharged at the given ampere rate, without harming the battery. Continued discharging below this value is not recommended. The designer should

Table II—Dimensions of Several Batteries Having Similar Capacities

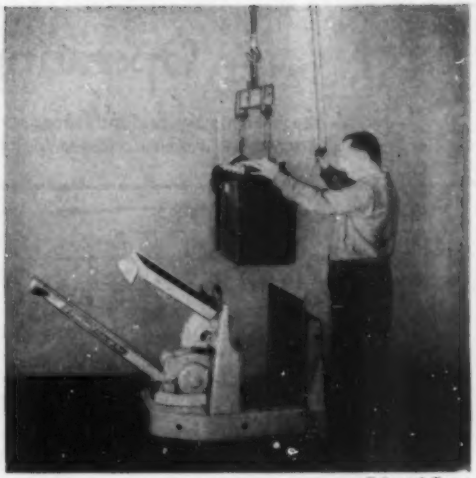
Ampere-hour capacity at the 6-hr rate	Cell Size in inches L W H	Number of plates per cell
442	10 3/8 x 6 1/4 x 15 1/8	27
440	8 7/8 x 6 1/4 x 16 1/4	23
440	6 5/8 x 6 1/4 x 20 3/4	17

Gould Storage Battery Corporation



Yale and Towne

Fig. 8—Louvers are often designed into the battery case to provide sufficient ventilation. Air circulation may be advisable.



Yale and Towne

Fig. 9—When lifting batteries from compartments by hoisting equipment, spreaders are used to avoid bending the structure.

not confuse high discharge rates (amperes) with over-discharge (too many ampere hours taken out). The former is harmless, but the latter will damage the battery if repeated frequently.

The unlabeled curve is a time curve and indicates the length of time required to discharge to final voltage, in this case, 9 minutes. Since the total time required to start a diesel is normally only a few seconds, there is little danger of the battery being discharged to final voltage during starting.

The solution to a starting problem is not always so simple. Usually the battery manufacturer has to be consulted, and he proceeds generally through these steps:

1. Determine the maximum cranking torque required.
2. Find the speed at which the engine must turn over to start.
3. Decide upon the maximum cranking action to be furnished—number of runs, interval between them, and duration.
4. From engine manufacturer get breakaway torque and rolling torque of engine.
5. Get characteristic curves of starter motor—torque-amperage and voltage-speed curves.
6. Make the calculations for every condition.

For low temperature applications, Fig. 3(B) is consulted and the above procedure is again followed: 1,200/110 equals 11 positives, requiring a 23 plate cell. Checking, now, for cranking, 600/50 equals 12 positive plates or a 25 plate battery. Therefore, the 25 plate battery would be selected.

Temperature is also an important factor in choosing railroad car lighting batteries, signal system batteries, and batteries for operating outdoor motive power equipment.

Ventilation should be provided for batteries that will be operated in high temperature locations. The designer should keep in mind the possible causes of high temperature. They can be due to climate or to high temperature equipment near the battery. To provide ventilation, louvers, Fig. 8, are often designed into battery boxes. Batteries are sometimes elevated from the bottom of the compartment by structural iron members, to assure complete air circulation. In extremely cold temperatures, insulation can be provided as an integral part of the battery compartment.

Although it does not enter into the selection of a battery, the design engineer should be familiar with the fact that temperature is important in another phase of battery technology—namely, charging. If the battery is charged too rapidly, the chemical reaction that takes place in charging will give off heat. This will cause the electrolyte to "gas" and water to evaporate from it. Continued high charge rates will have damaging effects on the plates of the battery. He should also be aware that the specific gravity method of measuring the state of charge is not too satisfactory. The acid may not be thoroughly diffused throughout the electrolyte at the time of the reading. Reading errors also creep in. It is better to use a voltmeter for this check. A battery voltmeter, having a 3-volt scale, is essential for accuracy.

The weight of the battery must sometimes be considered in designing battery powered equipment. For example, when used in industrial trucks, the battery can act as ballast, and often eliminates lead counterweights for load-balancing purposes. Structural elements also must be strong enough.

Good design should provide the utmost in convenience for installing and removing batteries. Their weight makes this aspect important to the user. Batteries are removed from vehicles by two methods: (1) By overhead hoist, Fig. 9, or (2) by rollers. When hoisting equipment is used, a spreader should be employed to eliminate any tendency toward bending. Rollers are often used where headroom is limited; in mines, for example.

In laying out battery compartments and specifying batteries, clearance for structural supports—such as angles and channels—must be provided.

The various types of charging plugs, length of charging lead, and cable connectors should be studied in advance to avoid make-shift arrangements by equipment operators. This is particularly so when replacement units are purchased.

For protection of the battery and the equipment it powers and for safety, batteries are often equipped with fuses. Two are required for system-governed and floating batteries. One protects the line to the power supply system; the other is in the line to the equipment. Both these lines run to the positive terminal of the battery.

Operating Principles of Various

Any of the many physical and chemical processes affected by temperature changes can be used for temperature measurement. Many of these are good for quantitative evaluation and

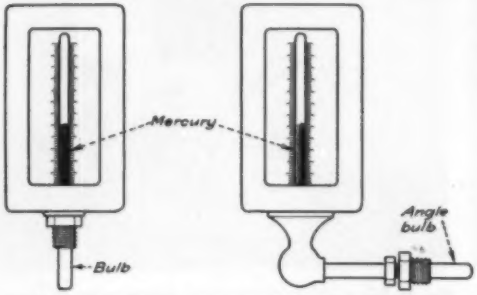


FIG. 1—The thermal expansion of liquids is the process most commonly used to measure temperatures. The most familiar device utilizing this process is the mercury in glass thermometer. Keeping the mercury under pressure increases its boiling point so that if quartz replaces glass in the container, temperatures as high as 650 C (1,202 F) can be measured. This can be accomplished by filling the stem with nitrogen at low temperature and sealing. The range of temperatures can be further extended by using specially selected liquids and container materials. When the container is opaque, a scale can be lowered from the top to make contact with the top surface of the fluid.

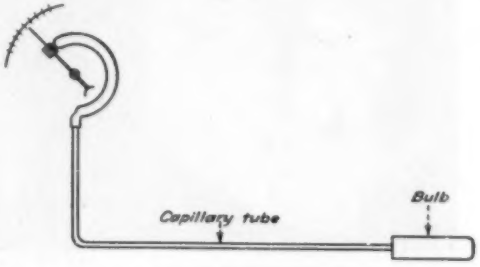


FIG. 2—When a liquid undergoing thermal expansion is confined in a vessel resisting its increase in volume, the pressure increases. This pressure increase then gives an indication of the temperature. In the arrangement shown, the pressure change causes the bourdon tube to actuate a pointer, recording instrument or control device. Instead of a liquid, a gas may be used. Also, in some cases, the liquid may be volatile in the range of temperatures for which the instrument is to be used. In systems with non-volatile liquids, when the bulb is far from the bourdon tube, compensation for thermal expansion (or contraction) of the liquid in the capillary tube may be required.

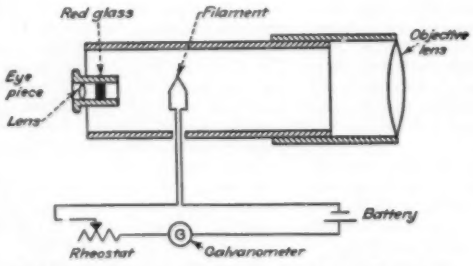


FIG. 5—Optical pyrometers measure high temperatures through the intensity of the red light waves emitted by the body under investigation. This intensity is compared with that of the red light waves emitted by a filament of known temperature. To accomplish this, the eyepiece is focused on the filament and the objective lense is focused to superimpose the image of the body under investigation. In the type of optical pyrometer shown here, the temperature of the filament is adjusted until it appears as bright as the hot body when viewed through the red glass in the eyepiece. The filament temperature adjustment is accomplished by changing the electric current passing through it. The measured value of current indicates the temperature.

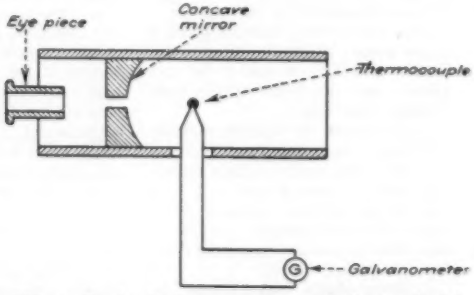


FIG. 6—Total radiation pyrometers are similar in principle to optical pyrometers. However, instead of dealing only with red light waves, it measures temperature through a determination of the total energy radiated from the body under investigation. In the type of radiation pyrometer shown here, the concave mirror focuses the waves radiated from the hot body whose temperature is to be determined on the thermocouple. The local temperature measured at the thermocouple indicates the temperature of the hot body. Total radiation pyrometers can be used for determining temperatures outside the practical range of thermocouples. In addition, they can be used where mounting other types of instruments is not feasible.

Temperature Measuring Devices

recording of temperature as well as the actuation of controls. Others are simply ways of indicating the thermal history, sometimes furnishing evidence that a machine has been abused.

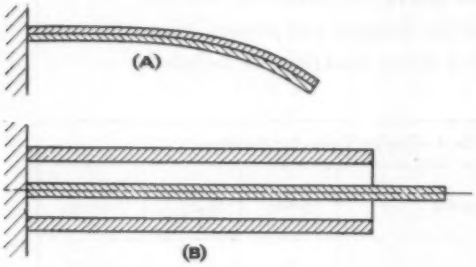


FIG. 3—The bimetal thermostat utilizes the difference in thermal expansion of different metals. In type (A) deflections are caused by the different thermal expansions of the two metal strips joined together lengthwise. Increasing the length of the strips increases the deflection. However, for the same thermal energy absorbed the force available for actuating controls is correspondingly reduced. Coiling the strips makes possible this increase in length without loss in compactness. In type (B), a rod passes through a tube of different material and is joined to that tube at one end. The difference in the expansions of the rod and tube causes a relative axial motion.

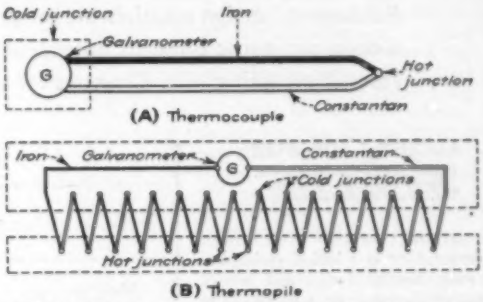


FIG. 4—The thermocouple consists basically of two electrical conductors of different materials joined together at both ends. They may be joined either directly or through some electrical conductor. An electromotive force approximately proportional to any difference in the temperatures of the two junctions arises because of thermoelectric effects. Measurement of this electromotive force indicates values of temperature. Thermocouples using conductors of various materials are practical for temperatures up to about 3,000 F. Since the electromotive force is small, a group of thermocouples in series, known as the thermopile, is used to measure small temperature differences.

FIG. 7—The resistance thermometer measures the change in electrical resistance accompanying a change in temperature. The resistance element illustrated is wound around two long rectangular pieces of mica intersecting at right angles along their longitudinal axis. Care is taken in this construction to allow for thermal expansion without excessive thermal stresses. Protection from contact with contaminating media is essential because electrical resistance is very sensitive to impurities. Resistance thermometers are very accurate in the range from —259 to 1,100 C (—434 to 2,012 F) although the necessarily large size of the resistance element is often a disadvantage. Vibration and shock damage resistance thermometers.

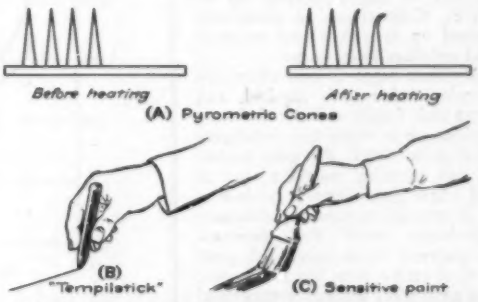


FIG. 8—(A) Pyrometric cones are placed in furnaces to show whether or not the temperature therein is properly controlled. These cones are used in sets where some of them soften at different temperatures than others. (B) A "Tempilstik" is a crayon leaving a mark that changes color when heated to its critical temperature. By using a series of marks from crayons with different critical temperatures, a series of measurements can be taken. (C) Special paints have been designed to change color when a critical temperature is exceeded. Paints with different critical temperatures have been developed. Machine parts thus painted supply evidence of abuse through overheating when the change in color occurs.

Simplified Design Procedure For Helical Wire Springs

Fundamental design equations are presented and new equations derived that contain parametric constants dependent on the diameter and physical properties of the spring wire. Constants for seven spring materials are included.

AUGUST J. KWOSSEK
Engineering Design Department,
Sperry Gyroscope Company,
Div. of the Sperry Corporation*

TO OBTAIN A DESIRED FUNCTIONAL PERFORMANCE in a helical spring application, several design and service requirements must be satisfied. The design requirements determine the working load that the spring is to deliver, the approximate diameter of the coils, the working height, and the type of end-turns on the spring. The operating conditions determine the material that is to be used.

Music wire is used for high quality springs where corrosion resistance is not required and operating temperatures are less than 225 F. Stainless steel has good corrosion resistance at operating temperatures up to 500 F. Z-nickel has good corrosion resistance and can be highly stressed up to 550 F. K-monel can be moderately stressed up to 450 F and possesses good resistance to corrosion.

Beryllium copper is used where fair corrosion resistance is required, and where high fidelity and electrical conductivity are of importance at temperature up to 300 F. Phosphor bronze has fair corrosion resistance, and is used where good electrical conductivity is required at operating temperatures below 300 F. Brass possesses fair resistance to corrosion, and good electrical conductivity, but at temperatures up to 300 F induced stresses must be kept low.

The design proportions of helical compression and extension springs are governed by several factors such as

P = working load, lb
S = design stress at working load P, psi
d = wire diameter, in.
D = mean coil diameter, in.
G = torsional modulus of the spring material, psi
f = deflection per active coil, in.
C = ratio of mean coil diameter to wire diameter, D/d

* *The data and opinions presented do not reflect the opinions or standard practice of the Sperry Gyroscope Company.*

Table I—Design Data for Springs

Material	Design Stress, 1,000 psi	Torsional Modulus, 10^6 psi	Deflection Constant, R
Music wire	70	11.2	0.01964
Stainless steel spring wire	50	10.5	0.01500
Z-nickel spring wire	60	11.0	0.01714
K-monel spring wire	50	9.5	0.01654
Beryllium copper spring wire	35	7.2	0.01527
Phosphor bronze spring wire	35	6.0	0.01833
Brass spring wire	25	5.0	0.01571

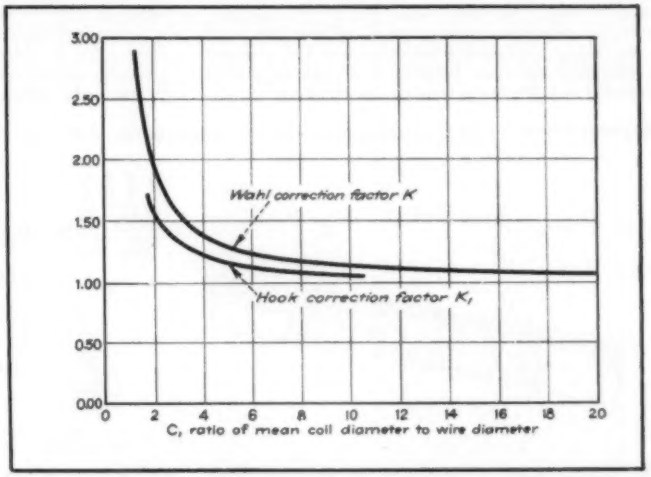


Fig. 1—Wahl correction factor, hook correction factor and the ratio of mean coil diameter to wire diameter. Factors are used for obtaining theoretical maximum stress.

These factors are related in the two fundamental spring equations thus*

$$P = \pi d^3 S/8D \quad (1)$$

$$f = 8PD^3/Gd^4 \quad (2)$$

$$= 8PCD^2/Gd^2 \quad (2A)$$

$$= \pi SCD/G \quad (2B)$$

In the usual spring design problem the given or known factors are: The working load P; the space considerations that determine D and those that determine the working height of the spring.

With P and D fixed, Eq (1) can be written in the form

$$PD = \pi d^3 S/8 = Q \quad (3)$$

in which Q is defined as a load constant.

The deflection f per active coil can be expressed similarly in terms of a

Table II—Values of Load Constant Q

Wire Dia d, in.	Music Wire	Stainless Steel	Wire Dia d, in.	Music Wire	Stainless Steel
0.010	0.0275	0.01964	0.055	4.57	3.27
0.011	0.0366	0.0261	0.059	5.65	4.03
0.012	0.0475	0.0339	0.063	6.87	4.91
0.013	0.0604	0.0431	0.067	8.27	5.91
0.014	0.0754	0.0539	0.071	9.84	7.03
0.016	0.1126	0.0804	0.075	11.60	8.28
0.018	0.1603	0.1145	0.080	14.07	10.05
0.020	0.220	0.1571	0.085	16.88	12.06
0.022	0.293	0.209	0.090	20.0	14.31
0.024	0.380	0.271	0.095	23.6	16.83
0.026	0.483	0.345	0.100	27.5	19.64
0.029	0.670	0.479	0.106	30.5	23.4
0.031	0.819	0.585	0.112	38.6	27.6
0.033	0.988	0.706	0.118	45.2	32.3
0.035	1.179	0.842	0.124	52.4	37.4
0.037	1.392	0.995	0.130	60.4	43.1
0.039	1.630	1.165	0.138	72.2	51.6
0.041	1.895	1.353	0.146	85.6	61.1
0.043	2.19	1.561	0.154	100.4	71.7
0.045	2.51	1.789	0.162	116.9	83.5
0.047	2.85	2.04	0.170	135.1	96.5
0.049	3.23	2.31	0.180	160.3	114.5
0.051	3.65	2.61			

Wire diameter d, in.	Z-Nickel	K-Monel	Beryllium Copper and Phosphor Bronze	Brass
0.0100	0.0236	0.01964	0.01374	0.00982
0.0113	0.0340	0.0283	0.01983	0.01417
0.0126	0.0471	0.0393	0.0275	0.01964
0.0142	0.0675	0.0562	0.0394	0.0281
0.0159	0.0947	0.0789	0.0553	0.0395
0.0179	0.1351	0.1126	0.0788	0.0563
0.0201	0.191	0.1594	0.1116	0.0797
0.0226	0.272	0.227	0.1587	0.1133
0.0253	0.382	0.318	0.223	0.1590
0.0285	0.545	0.455	0.318	0.227
0.0320	0.772	0.643	0.450	0.322
0.0359	1.090	0.908	0.636	0.454
0.0403	1.542	1.285	0.900	0.643
0.0453	2.19	1.825	1.278	0.913
0.0508	3.09	2.57	1.802	1.287
0.0571	4.39	3.66	2.56	1.828
0.0641	6.21	5.17	3.62	2.59
0.0720	8.79	7.33	5.13	3.66
0.0808	12.43	10.36	7.25	5.18
0.0907	17.58	14.65	10.26	7.33
0.1019	24.9	20.8	14.54	10.39
0.1144	35.5	29.4	20.6	14.70
0.1285	50.0	41.7	29.2	20.8
0.1443	70.8	59.0	41.3	29.5
0.1620	100.2	83.5	58.4	41.7
0.1819	141.8	118.2	82.7	59.1
0.2043	201.	167.4	117.2	83.7
0.2294	284.	237.	165.9	118.5

deflection constant R by rewriting Eq (2B) thus

$$f = \pi SCD/G = RCD \text{ or } R = \pi S/G \quad (4)$$

Using Eq (3) and the design stresses given in Table I, values of Q have been calculated for different wire diameters and spring materials. These values of Q are given in Table II. The design stresses given in Table I are conservative values. They must be multiplied by the Wahl correction factor K to obtain the theoretical maximum stress S_{max} induced in the spring under the working load P, that is, where

$$K = \frac{4C-1}{4C-4} + \frac{0.615}{C} \quad (5)$$

$$S_{max} = SK \quad (6)$$

In Table III are given values of K computed from Eq (5) for values of C ranging from 1 to 20. The curves in Fig. 1 are plotted for these values. When the ratio C of mean coil diameter to wire diameter has a value of 4, the spring will be "hard," that is, the deflection f per active coil will be small. When C has a value of 18 the spring will be soft, that is, the deflection f will be large. In his first edition of "Mechanical Springs," A. M. Wahl states "It should be noted that in actual springs with C greater than 2.5 and pitch angles less than 15 deg the deviations between the ordinary deflection equation and the more exact equations will be less than 2.5 percent. The error approaches 15 percent for initial pitch angles near 20 deg, and deflections per turn equal to the initial coil radius."

The values of R given in Table I for the different spring materials were calculated by Eq (4) using the design data given in the first two columns.

It is obvious, from equations presented, that for physically identical springs made of different spring materials the values of Q for the materials are in direct proportion to the load capacity of the springs, and the values of R are in direct proportion to the

Table III—Values of Wahl Correction Factors for Different Ratios of Mean Coil Diameter to Wire Diameter

C	K	K_1
1.0	∞	
1.5	2.910	
2.0	2.058	1.60
2.5	1.746	
3.0	1.580	1.34
3.5	1.476	
4.0	1.404	1.23
4.5	1.351	
5.0	1.311	1.17
5.5	1.279	
6.0	1.252	1.14
6.5	1.233	
7.0	1.213	1.12
7.5	1.199	
8.0	1.185	1.10
8.5	1.172	
9.0	1.162	1.08
10.0	1.145	1.07
11.0	1.131	
12.0	1.120	
13.0	1.109	
14.0	1.102	
15.0	1.094	
16.0	1.088	
17.0	1.033	
18.0	1.078	
19.0	1.074	
20.0	1.070	

Table IV—Equations for Springs With Different Types of Ends*

To Obtain	Plain End	Plain and Ground	Squared	Squared and Ground
h, Solid height n, Active coils	$d(N+1)$ N	$d(N+\frac{1}{2})$ $N-\frac{1}{2}$	$d(N+1)$ $N-2$	dN $N-2$
p, Pitch	$\frac{L-d}{N}$	$\frac{L}{n}$	$\frac{L-3d}{n}$	$\frac{L-2d}{n}$
L, Free length	$(p \times n)+d$	pn	$(p \times n)+3d$	$(p \times n)+2d$
N, Total coils	$\frac{L-d}{p}$	$\frac{L}{p}$	$\frac{L-3d}{p}$	$\frac{L-2d}{p}+2$

* Table from "Accurate Handbook of Technical Data on Springs," Accurate Spring Mfg. Co.

deflection per active coil of the springs.

The manner in which the end turns of the spring are formed or finished affects the calculations for determining the solid height h, the number of active coils n, the pitch p, the free length L, and the number of total coils N. For the four common types of ends shown in Fig. 2, Table IV gives equations for calculating these factors.

Loops at the ends of extension springs, Fig. 3, are subjected to both bending and torsional stresses. The magnitude of the combined stresses is greatest at the base of the loop, therefore, this spot is the weakest point of an extension spring. To make sure that the spring is safe, the maximum induced stresses should be calculated and compared with the maximum permissible for the material.

In springs with loop ends, Fig. 3, the maximum torsion stress S_{mt} occurs at Point A, while the maximum bending stress S_{mb} occurs at point A'. A. M. Wahl in his book "Mechanical Springs" states that

$$S_{mt} = \frac{16\,Pr}{\pi d^3}\left(\frac{4C_1-1}{4C_1-4}\right), \quad \text{where } C_1 = 2r_1/d \qquad (7)$$

$$S_{mb} = \frac{32\,PrK_1}{\pi d^3} + \frac{4P}{\pi d^2} \qquad (8)$$

Values of K_1 are given in Table III, and Fig. 1 shows a plot of these values.

The magnitude of the Pr product term in Eqs (7) and (8) can be reduced by using a smaller diameter for the last coil before the loop of the spring. The decrease in maximum induced stress will be in direct proportion with the decrease in the magnitude of the Pr product term.

To demonstrate the use of the data or tabular values given in Tables I, and II two spring design problems will be solved.

EXAMPLE 1. Design a stainless steel, compression spring that will satisfy the following design requirements and operating conditions:

Load $P = 10$ lb
Working height $H = 1.5$ in

Spring to work inside a 0.625 in. dia hole; spring ends to be squared and ground.

SOLUTION. Assume value of 0.500 in. for the mean diameter D of the coil. Then from Eq (3), the value Q is

$$Q = 10 \times 0.500 = 5.00$$

From Table II, under the column headed stainless steel, the value Q nearest to 5.00 is 4.91 for which the wire diameter D is 0.063 in. Taking 4.91 as the value of Q, then from Eq (3)

$$D = \frac{Q}{P} = \frac{4.91}{10} = 0.491 \text{ in.}$$

then

Outside diameter $= 0.491 + 0.063 = 0.554$ in. and

$$C = D/d = 0.491/0.063 = 7.8$$

this value of C will yield a medium "hard" spring.

From Table I, the value of the deflection constant R for stainless steel is 0.01500. Then from Eq (4), the deflection f per active coil is

$$f = RCD = 0.01500 \times 7.8 \times 0.491 = 0.0575 \text{ in.}$$

Assuming that there shall be 10 active coils in the spring, Table IV indicates that for squared and ground ends the total coils N is

$$N = n + 2 = 10 + 2 = 12$$

and the solid height h of the spring is

$$h = dN = 0.063 \times 12 = 0.756 \text{ in.}$$

Checking this value against the working height of the spring indicates that the spring will not be closed solid at the working level, and that there will be clearance between the coils.

The total deflection F is

$$F = fn = 0.0575 \times 10 = 0.575$$

The free length L equals the working height plus the total deflection or

$$L = H + F = 1.5 + 0.575 = 2.075 \text{ in.}$$

From Table IV the pitch p is

$$p = \frac{L-2d}{n} = \frac{2.075 - 2 \times 0.063}{10} = 0.195 \text{ in.}$$

EXAMPLE 2. Design a beryllium copper compression spring that will satisfy the following design requirements and operating conditions.

Spring to work inside a 0.687 in. dia hole; spring ends to be squared and ground.

Spring is required to deliver a working load of 3 lb in one position, and also to deliver a working load of 6 lb in a second position that is at a distance of 0.375 in. from the first position.

SOLUTION. Assume a trial mean diameter D_1 of approximately 0.600 in. Then for the larger working load

$$Q_1 = PD_1 = 6 \times 0.600 = 3.600 \text{ approximately}$$

From Table II, the value of Q nearest 3.600 is 3.62, and a wire diameter

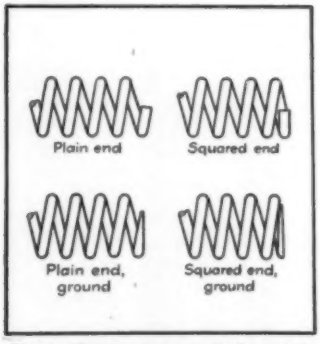


Fig. 2—Four common methods used in forming the ends of helical springs.

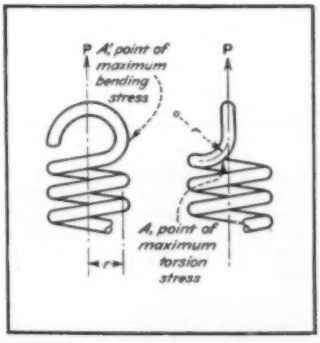


Fig. 3—Points of maximum torsion stress and maximum bending stress in loop end.

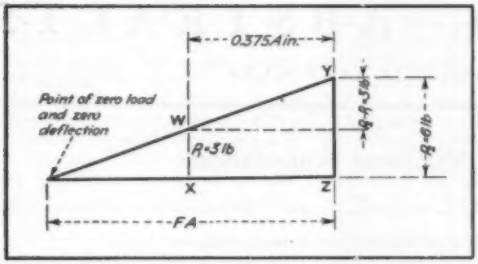


Fig. 4—Load-deflection diagram for determining the total deflection of spring when load is specified for two positions.

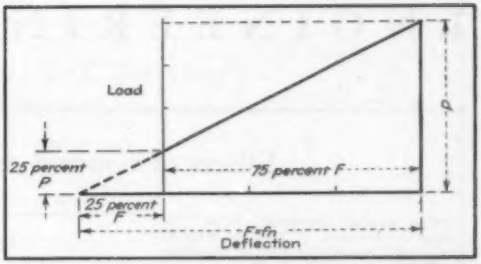


Fig. 5—Force-deflection diagram for an extension spring having 25 percent initial tension. Dash line is load before deflection.

d of 0.0641 in. is indicated. Actual mean diameter D then is

$$D = 3.62/6 = 0.603 \text{ in.}$$

and

$$C = 0.603/0.0641 = 9.4$$

From Table I the constant R for beryllium copper

$$R = 0.01527$$

and the deflection f per active coil is

$$f = RCD = 0.01527 \times 9.4 \times 0.603 = 0.0865 \text{ in.}$$

The total deflection F can be determined with the help of a load-deflection diagram, Fig. 4. In this diagram, WX is a scalar distance of 3 lb, representing the load at the first position of the spring; YZ is a scalar distance of 6 lb, representing the load at the second position of the spring; and length XZ is 0.375 in. times some constant A. Then from similar triangles

$$\frac{FA}{6} = \frac{0.375A}{3}$$

or the total deflection F of the spring under the larger working or second position is

$$F = \frac{0.375 \times 6}{3} = 0.75 \text{ in.}$$

The number of active coils n, then is

$$n = F/f = 0.75/0.0865 = 8.67$$

use 8¾ active coils

From Table IV

$$N = n + 2 = 8\tfrac{3}{4} + 2 = 10\tfrac{3}{4} \text{ total coils}$$

$$h = dN = 0.0641 \times 10.75 = 0.689 \text{ in.}$$

$$L = h + F = 0.689 + 0.75 = 1.439 \text{ in. free length}$$

$$p = \frac{L - 2d}{n} = \frac{1.440 - 2 \times 0.0641}{8.75} = 0.150 \text{ in. pitch}$$

All information presented in the foregoing discussion for the solution of compression spring design problems also applies to extension spring designs. The solution for the physical dimensions of the body of an extension spring is identical to that for a compression spring close wound without initial loading.

If an extension spring be given an initial tension, the spring will not begin to extend until the initial tension has been overcome. The initial tension can be made as much as 25 percent of the design load. The deflection necessary to produce the design load will then be 75 percent of the value calculated from

$$F = fn$$

The force-deflection diagram Fig. 5 shows the relation between load and deflection in an extension spring having 25 percent initial tension.

Calculations based on the data given in this discussion will possess a greater degree of accuracy than one can expect to find in manufactured springs. A variation of plus or minus ten percent in load characteristics may be expected in springs of commercial manufacture. In the manufacture of wire and springs there are permissible variations from nominal dimensions that must be accepted. Tables V, VI, VII, and VIII, present the commercial tolerances given in "Accurate Handbook of Technical Data on Springs" published by the Accurate Spring Manufacturing Company.

Grinding tolerances for squareness of spring ends are designated by numbers: No. 1 grinding is within 1 deg of square with the spring axis, No. 2 grinding is within 2 deg, and No. 3 is within 3 degrees.

In applying tolerances to spring designs and on detail drawings of springs, the tolerances given here should be specified only where absolutely necessary. Where larger tolerances can be accepted, they should be specified. Greater accuracy than is necessary in the manufacture of springs will increase manufacturing costs without increasing functional precision.

Table V—Drawing Limits for Music Wire

Wire Dia., in.	Tolerance, in.	
	Plus	Minus
0.006 to 0.016	0.00025	0.0000
0.017 to 0.062	0.0005	0.0000
0.063 to 0.081	0.0010	0.0000
0.082 to 0.104	0.0010	0.0010
0.105 to 0.144	0.0015	0.0015
0.145 and up	0.0020	0.0020

Table VI—Outside Diameter Tolerance

Outside Diameter, in.	± Tolerance, in.
Below 1/8	0.003
1/8 to 1/4	0.005
1/4 to 1/2	0.008
1/2 to 1	0.015
1 to 2 1/2	1/32
2 1/2 to 4	1/16
Over 4	3/32

Table VII—Coil Tolerance

Coils	± Tolerance, Coils
4 or less	1/4
4 to 8	1/2
8 to 15	3/4
15 to 25	1
Over 25	2

Table VIII—Length Tolerance

Length, in.	± Tolerance, in.
Less than 1/2	1/64
1/2 to 1	1/32
1 to 2	3/64
2 to 3	1/16
3 to 5	3/32
5 to 8	1/8
8 to 12	3/16
12 to 18	1/4
18 to 24	3/8
24 to 30	1/2
Over 30	3/4

Effects of Ground on Machine Foundations

Foreign abstract condensed from "The Dynamic Principles of Machine Foundations and Ground" by J. H. A. Crockett, B. Sc. (Eng.) and R. E. R. Hammond. Presented at an Extra General Meeting of The Institution of Mechanical Engineers, April 8, 1949. Published by The Institution, Storey's Gate, St. James' Park, London, S. W. 1.

RESEARCH ON SOIL DYNAMICS and machine foundations has revealed that there are correct design principles for vibrating foundations. These can be used without dependence on empirical methods.

Through extensive research both by themselves and by others, the authors conclude that any ground can oscillate at its own particular natural frequency. Further, they found that machines and ground quite often vibrate in resonance. A table showing some measured self-frequencies and corresponding bearing values for various soil is presented in the paper, and a portion is given here as Table I.

Machine foundation systems can be treated as spring-weight systems. For some systems the stiffness of the spring

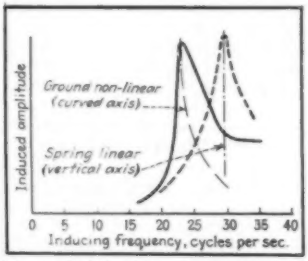

Induced amplitude
Ground non-linear (curved axis)
Spring linear (vertical axis)
0 5 10 15 20 25 30 35 40
Inducing frequency, cycles per sec.

Fig. 1—Relationship of non-linear and linear resonance load-deflection curves.

is linear, but for materials such as cork and rubber, the load-deflection relation is non-linear. For such cases, the resonance peak loses its symmetry, and bends as indicated in the curve, Fig. 1, about a curved axis.

This figure shows a resonance curve from a soil in which the peak is at 23.12 cps. If the amplitude induced at resonance had been much smaller, this resonance frequency would have been higher; if it had been larger than shown, the resonating frequency would have been lower. In practice, frequencies do not vary more than about 25 percent below their highest values for small amplitudes of movement. Although these variations may not amount to much, the designer should consider the self-frequency of the ground for any site.

Table I—Frequency and Bearing Values of Soils

Type of Soil Values from Andrews and Crockett (1945–7)	Frequency, cps	Admissible pressure, tons per sq ft
Peat	7.5	.....
Waterlogged estuarine silt	10	0.7
Very light soft clay	12	1.0
Light waterlogged sand	15	1.5
Medium clay	15	2.0
Hard peat and sand layers	17	2.0
Stiff clay	19	3.0
Silt and sand mixed	23.3	3.0
Sand and rubble loosely compacted	23.5	3.0
Limestone	30	.....
Granite	40	.....

The relation between phase and induced frequency demonstrates further the analogy between a foundation on the ground and a single spring-weight system. Changes of phase show that extra power is needed to overcome the effect of resonance with the ground. This is shown by the curves in Fig. 2, which are based on a certain machine. The changing power requirements occur because the displacement is in or out of phase with the inducing force. Curve *a* shows power required by machine when it is well-balanced; Curve *b* shows extra power required by additional friction in bearings when machine is out of balance; Curve *c* shows the large amount of energy dissipated by including oscillations in ground in zone of resonance.

There is a portion of ground that is immediately below, and acts with, the foundation weight. However, since this active ground weight is springy, its weight becomes the weight of the spring. It was shown by earlier investigators that an ellipsoidal zone exists under the area of contact between one body and another. Within this zone, all principal lines of stress are in compression. Outside of it, some of the lines change to tension. Lines of "hoop stressing" also occur around the outside of the inner ellipsoidal compressed portion. Diagram in Fig. 3 illustrates this action.

A discussion on the variations of this bulb of pressure follows. From the fact that the weight of the ground within the bulb is always constant, a spring constant (K_{stm}) is derived in equation form. The dynamic elasticity from this constant is usually several times greater than the static elasticity.

A settlement of the ground occurs connected with the rapid rise in power output needed to carry the machine through the resonance zone of ground and foundation. It is particularly rapid within the resonance range.

Further discussion on ground includes: The damping coefficient and loss of energy outwards; frequencies of several underlying strata. Various

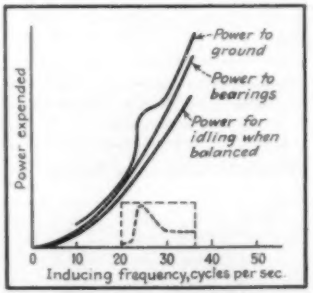

Power expended
Power to ground
Power to bearings
Power for idling when balanced
0 10 20 30 40 50
Inducing frequency, cycles per sec.

Fig. 2—It can be seen from the curves that a greater loss of machine power to ground occurs at resonance.

curves help to simplify the discussion.

In designing foundations, the main problem is selection of size and stiffness for weights and springs to prevent troublesome vibration. Furthermore, resonance must not be allowed between the normally running machine and the spring-weight system, nor with the ground. The self-frequency of any adjacent structure and its chief harmonics can be nearly as important as those in the ground. It is not yet possible to calculate satisfactorily the constants for the cork springs used around and under foundations. A common way of building "anti-vibration" machines is with cork spring

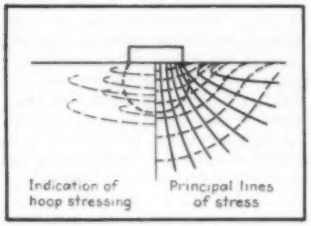


Fig. 3—Stress lines in a bulb of pressure that theoretically exists in the active ground mass under a machine foundation.

pads surrounding the sides and under the middle block. Movement of the ground and concrete in this instance is only reduced by 30 percent, because of the stiffness of the cork.

Plates of Lissajous figures show simple harmonics, variation of damping, difference of phase, variations of initial velocity in each dimension, and almost linear conditions, but there are very few degrees of freedom. It is impractical to compute oscillational behaviour of machine foundations having twelve or eighteen degrees of freedom (triple spring-weight systems) unsymmetrical proportions, harmonics, variable conditions, non-linear spring constants, and damping. If a single dimension is changed, the movement may be entirely altered. It is probably practical to calculate, in all degrees, a single spring-weight system.

Trend in Oscillation-Controlled Foundations

A good base plate, a concrete block or other type of balance weight arrangement, and a main, pit-type foundation in contact with the ground are required by all oscillation-controlled foundations. Helical or volute springs and spring pad materials can be used directly under the machine or top weight. Leaf springs must be used with suspension bars as they are unable to oscillate usefully in either longitudinal or lateral directions.

Fig. 4 shows an economical method of supporting and controlling an unsymmetrical plant. In it, the machine, the impulses imparted to the ground, and the total mass distribution are all symmetrically arranged. Calculations are, thus, simplified. This method can be further simplified by supporting at the level of the mass center, when rotations and translations remain separated.

High frequency stress waves are treated at length in the paper. Simplified theory; action of sand, gravel, and other insulating layers, self-induced stress wave build-up; conditions in surfaces not completely in contact, and stress waves through "plums" are some of the divisions of the sections. Two tables are given on high frequencies. One shows velocities of P stress waves for different materials, the other shows reflection and refraction of stress waves at surface boundaries. A diagram illustrates successive refractions and reflections at two boundaries between three materials.

From this work principles of design for the foundations of reciprocating machinery are derived: (1) Any machine-foundation system can be considered as a series of weights and springs. Simple vibration analysis may be applied. (2) The six degrees of freedom of every component of a spring-weight system must be considered at every stage of design. (3) The ground is itself a spring-weight system. Therefore, the self-frequency for

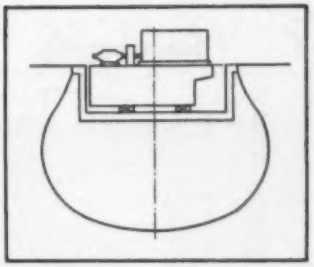


Fig. 4—Symmetrical foundation system planned for an unsymmetrical plant.

each site must be determined and checked periodically during construction. (4) The ground and any foundation on it can most probably oscillate at determinable frequencies in six degrees of freedom. (5) Resonance between ground and machine resulting in loss of power should be prevented. (6) Resonance between ground and machine should be prevented if settlement is undesirable. (7) Where resonance between ground and machine cannot be avoided, the basic methods commonly used in other spring-weight systems can be adopted. (8) Simple design is the best. (9) Stress waves must be considered in all stages of design. (10) Boundary surfaces should be as accurate as possible to avoid local stress concentrations and chattering.

The authors have prepared a bibliography of over 1,000 works. These include publications of researchers over all the world.

Tapered Skin-Plating

Foreign Abstract from "Tapered Skin-Plating; Weight Economy, Design and Manufacturing Considerations," *Aircraft Production*, London, September, 1949.

A RECENT DEVELOPMENT in aircraft constructional technique is the use of tapered skin-panels to save weight by distributing the material in proportion to the loads the material carries. Aluminum alloy structural members can be machined in several ways with local thick areas, thick edges, steps or straight tapers to satisfy such requirements.

The North American Aviation Company of Los Angeles, California, state that the ease and speed of producing and assembling tapered metal sheets compare favorably with the manufacture of conventional assemblies of multiple-thickness skins and doubling plates.

Types of tapered sheets so far considered fall into the three groups shown in Fig. 1. They are: Sheets in which the taper is formed uniformly from end to end by machining or by rolling; thickness reduced in steps of uniform thickness by machining only;

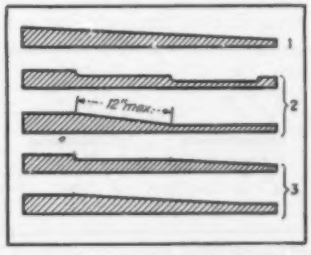


Fig. 1—Types of tapered sheet produced by machining or rolling aluminum alloys.

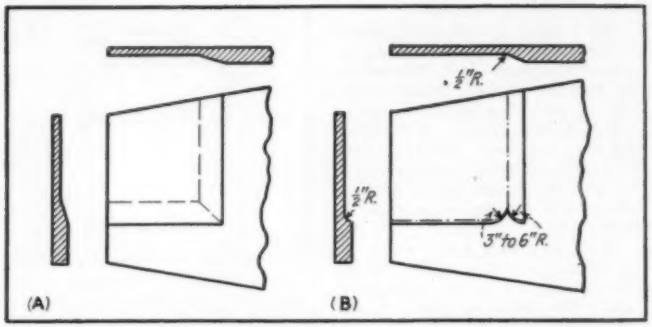


Fig. 2—(A) Blending right angle cuts at internal corner not practicable. (B) One method of blending a radius and an angular cut. Controlling machine requires skill.

and by combining these two types.

The design of the tapered skin should be such that it can be machined by straight cuts parallel with, or at 90 deg to, the traverse of the machine table. Profile cuts and angular cuts can be guided by template and stylus. Areas of reduced thickness completely surrounded by thicker sections must be avoided.

Certain types of internal corner cuts can be obtained only with skillful handling of the machine controls. A square corner such as is shown in Fig. 2(*A*) is not practicable; a blend of two radii, or a radius and a plane cut as shown in Fig. 2(*B*), should be specified.

Tapered sheets can be formed on a press brake into angles or channels and stretched to contour.

Advantages claimed for sheets tapered by milling include the following. Weight is reduced through removal of excess metal in areas where the thickness is greater than that required to withstand load. Joints between members of different thickness are avoided with saving in assembly time and in weight of butt straps and fasteners. Edges of sheets may be left thick, thus increasing the bearing strength for attachment and reducing the number of fasteners.

The disadvantages include the fallowing. Removal of the pure aluminum protective cladding from one side of the sheet, consequently, it is necessary to anodize. Selection of grip lengths of blind fasteners is complicated by the taper, hence the length of fasteners must be carefully controlled according to the particular area in which they are to be installed.

Non-Destructive Testing of Small Brazed Joints

Foreign abstract from "Brazed Tool-Tips", Aircraft Production (London) p. 295, September, 1949.

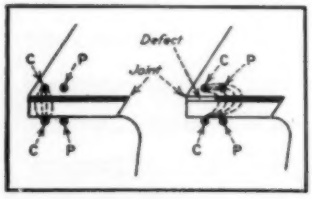
WITH THE WIDESPREAD USE of carbide-tipped tools, corresponding attention must be given to the efficiency of the brazed joint. It is essential that they be kept free from even small adhesion defects, particularly where the joint area is small.

This need for perfect joints led up to the development of the non-destructive method of testing described in this article. Based upon electrical methods it appears to be particularly adaptable to a wide range of applications.

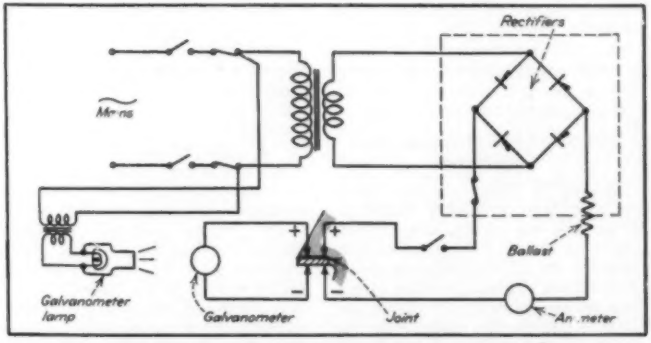
The test consists of measuring the resistivity of the brazed joint. It uses the effects of a current path passing at right angles through the joint to acute a mirror galvanometer. In practice, four contact points are used, and are arranged so that they straddle the joint in pairs. One pair of contacts applies a current across the joint and the other pair, called the potential contacts, are connected to a sensitive galvanometer.

The potential contacts are close enough to the current contacts (3/32 in.) to be affected by any change in the current path through the joint. Any deflections in the path of current through the joint produce proportionate responses of the galvanometer. If, for example, there is a local defect, such as a small air-gap in the joint, the current path will be distorted by an amount roughly proportional to the extent of the defect. The longer path of current flow means a greater voltage drop and, thus, an increase in the voltage across the potential contacts.

The current contacts are supplied with d-c current from a transformer-rectifier circuit, with a ballast resistance that reduces the applied current to 2 amp. This limitation is necessary to safeguard the rectifier against accidental short-circuiting. For checking purposes, an amimeter is also used, functioning independently of the galvanometer. It is possible to ascertain that the current path is complete.

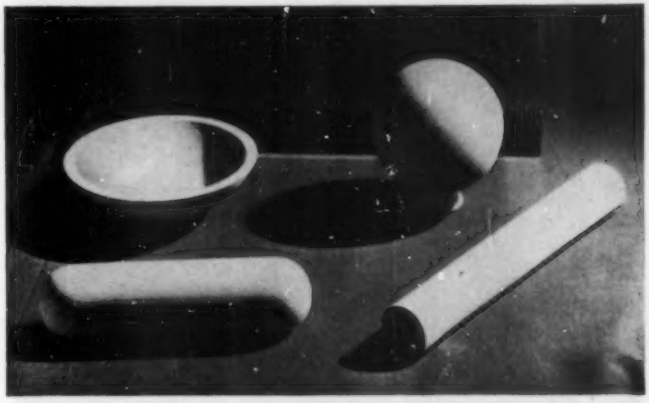


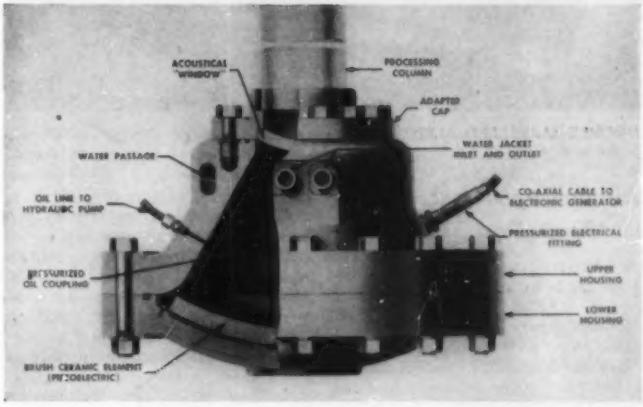
Current and potential contacts bracket the joint during a test set-up. Where defect is encountered, current path shifts.



Circuit diagram for testing small brazed joints. Rectified current of a constant value passes through the joint. The galvanometer measures the voltage drop which is proportional to the length of the current path.

Piezoelectric Ceramic Spurs Ultrasonics' Use





CERAMIC TRANSDUCERS (top) can be molded in various shapes for specific uses. Disk-shaped element is shown (cutaway view) at base of oil "energy coupling".

RECENTLY DEVELOPED Hypersonic equipment containing special ceramic transducers promises to open the way to widespread experimentation and new industrial applications of ultrasonic energy. The Brush Development Company of Cleveland has produced three different standard sizes of equipment—a laboratory, a pilot plant and a custom-made production model. The laboratory equipment is expected to help researchers in many fields to apply ultrasonics to speed up existing production techniques and to develop new procedures (PRODUCT ENGINEERING —November 1949, page 153). The larger models will come into use once laboratory studies dictate the need for production equipment.

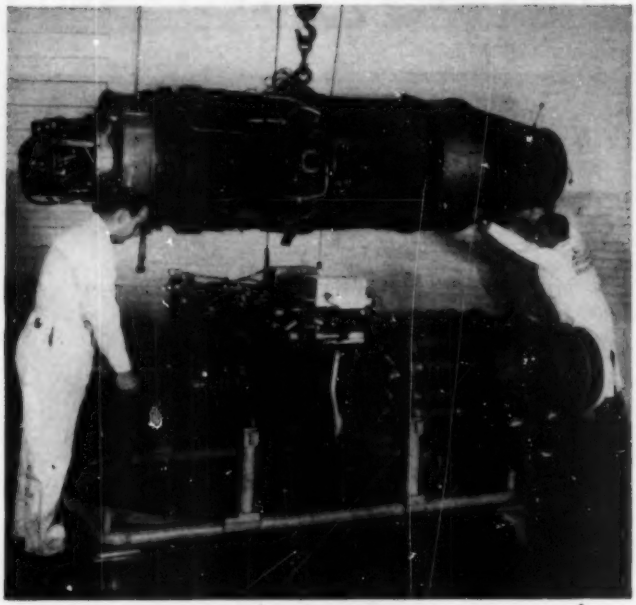
Heart of the transducer is the ceramic element that produces ultrasonic energy when excited by an electronic generator. Traditionally, quartz crystals have played the role of this piezoelectric element. But the small size and short supply of natural quartz, and the extreme cost of artificial quartz crystals have necessitated experimentation with other materials.

Barium titanate with several additives, specially polarized during fabrication, was found by Brush engineers to be best suited for ultrasonic applications. The ceramic has the advantage over standard piezoelectric elements of having "direction control"—the mechanical action or line of radiation of the energy can be made to follow a predetermined direction depending on the method of polarization during the element's manufacture. This technique permits wide latitude as to the molded shape of the transducer element. The ultrasonic energy can be focused along the axis of a tubular element, or concentrated at the center of a sphere or focal point of a concave surface. Energy densities within the focus area are in the order of thousands of watts per square inch.

A second feature of the transducer is "energy coupling" to the work load. As shown in the cutaway view, oil under 600 to 1,000 psi pressure is used to "couple" the ceramic element and the work, the metal diaphragm at the top acting as an "acoustical window" and as a seal for the oil reservoir. Cavitation in the oil is thereby suppressed and efficient coupling maintained throughout the body of oil.

The laboratory model generator equipment spans the frequency range from approximately 300 to 1,000 kc. The standard transducer supplied with the laboratory equipment is designed for operation at 400 kc, although other transducers of any frequency within the above range can be supplied. The pilot plant equipment designated as Model BU-102 is designed for operation at 125 kc and contains the transducer shown.

Ultrasonic energy can be applied not only in industrial manufacture, but also in biological and agricultural fields. Some of the industrial uses are: Emulsification of oil and water soluble liquids, mercury and water mixtures; transformation of crystal structures; vaporization of liquids of all types; degassing of liquids; dispersion of metals in electrolysis production operations; degreasing of metal; mixing of powdered metals for manufacture of cemented carbide tools, pigment and vehicle in paint manufacture; agglomeration of smoke and dust particles; dispersion of metallic elements in water, alcohol or oil; high-speed dyeing of fabrics and plastic materials.



DOUBLE-BARRELLED ALLISON turbo-prop engine (bottom) develops about same power as G. E.'s J-35 unit (top), yet has only two-thirds its unit diameter and length.

Allison's 5,500-hp Engine Combines Two Turbos

A NEW TURBINE-DRIVEN aircraft engine has been announced by officials of the Allison division, General Motors Corporation. The new XT40 turbo-prop was developed for the Navy and is scheduled for installation in the Navy's new four-engined Consolidated Vultee XP5Y long-range patrol bomber.

The engine develops 5,500 horsepower, though weighing only half as much as conventional piston engines of the same output, and its fuel economy "approaches the efficiency of those same engines."

The powerplant consists of two small-diameter, 17-stage axial-flow gas turbines similar to those used in some jet-propelled planes, except that 90 percent of the energy developed is translated into mechanical power. Two three-bladed counter-rotating propellers are driven through a 15.7-to-1 system of reduction gears and co-axial extension shafts.

The two power sections are designed to operate as a single unit during take-off, but either can be shut off after reaching cruising altitude and the other operated at the high-speed setting where turbine engines attain their greatest degree of operating efficiency.

"Development of the XT-40 will greatly speed the obsolescence of reciprocating engines in both military and commercial aircraft," E. B. Newill, Allison vice-president and general manager, said. "By matching the fuel economy of our best reciprocating engines and producing twice as much power for each pound of weight, the XT-40 rounds out the military requirement for an engine of the gas turbine type that will transport payloads over long distances at high speeds and altitudes."

Simple Rig Cuts Cost Of Relining Bearings

A DEVICE for relining diesel engine bearings by pouring molten babbit into the bearing as it revolves has been developed by Harold Webb, superintending marine engineer for the Seattle Port of Embarkation. This process of casting by centrifugal force results, it is claimed, in a finished product of higher quality and greater durability than that derived from the old method of fixed pouring. The metal is packed more tightly and evenly, air bubbles are eliminated and more of the impurities settle near the surface where they can be removed by machine. Older methods also require more material.

The bearing halves are clamped to a circular adapter and spun by a 3-hp electric motor at a speed of about 600 rpm. The 14-in. steel-faced adapter plate has four slots to accommodate bolts that hold the pot chuck and an outer face plate having a "pour" hole in the center. Asbestos placed between the bearing halves permits insertion of a hacksaw blade for cutting the babbit spun solidly around the bearing.

ME and EE Courses Combined at Lehigh

A SIGNIFICANT STEP in the evolution of engineering curricula has been taken at Lehigh University, Bethlehem, Pennsylvania. Two new five-year programs have been announced. One will include the degree of Bachelor of Science in Mechanical Engineering at the end of four years and that of Bachelor of Science in Electrical Engineering at the end of the fifth year; the other will give a student the opportunity to receive degrees of Bachelor of Science in Industrial Engineering and Business Administration at the end of five years.

Explaining the combined electrical-mechanical project, Loyal V. Bewley, head of the Department of Electrical Engineering, said that it is impossible to design an electrical machine or a power plant without encountering as many mechanical as electrical problems.

JAMES C. ZEDER, Chairman of the Engineering Board, the Chrysler Corporation took over the helm of the Society of Automotive Engineers at the annual meeting held in Detroit last month.

Washington Notes

Scientists Do Not Favor FBI Clearance Under NSF

If Congress should require FBI clearance for all those who receive government scholarships, fellowships or research grants under the much-delayed National Science Foundation bill, some scientists will prefer not to see this proposed federal science body created.

Many scientists who attended the recent meeting of the American Association for the Advancement of Science are not enthusiastic about Congress requiring even nonsubversive affidavits from scientists, but they will rebel definitely over FBI clearance, just as the National Academy of Sciences did in connection with Atomic Energy Commission fellowships.

The Intersociety Committee on the National Science Foundation voted to swallow the proposed rider requiring affidavits, but it concurred with the National Academy of Sciences for its stand in connection with the AEC grants.

Thermal Data for Gases Compiled by NBS and NACA

A project to make up tables giving thermal data on wind-tunnel and jet-engine gases has been started by the National Bureau of Standards in cooperation with the National Advisory Committee of Aeronautics.

The program calls for the critical evaluation of available data and preparation of convenient tables of 13 different thermal properties for each of 13 gases. Additions to the list of gases and properties to be tabulated are expected as the project develops.

Recent advances in jet propulsion and high-speed flight have emphasized the need for accurate thermal data on gases that flow through wind tunnels or jet engines, or are encountered in the atmosphere by guided missiles. As now planned, the tables will contain thermal data on these gases: dry air, moist air, steam, hydrogen, oxygen, nitrogen, carbon dioxide, carbon monoxide, nitrogen dioxide, nitric oxide, helium, freon 12(CF_2Cl_2), and argon.

The properties to be tabulated-in general as functions of both temperature and pressure—are heat capacity at constant pressure, enthalpy (total heat), entropy, Gibbs free energy, compressibility factor, density, ratio and specific heats, velocity of sound, relaxation parameters, viscosity, thermal conductivity, Prandtl number and vapor pressure.

These data will cover a range from low pressures up to 100 atmospheres, and from very low temperatures, such as occur in high-speed wind tunnels, to 3000 K—a temperature encountered in jet engines and at the wing surfaces of high-speed aircraft.

Cycloidal Disk Propellers Simplify Ship Steering

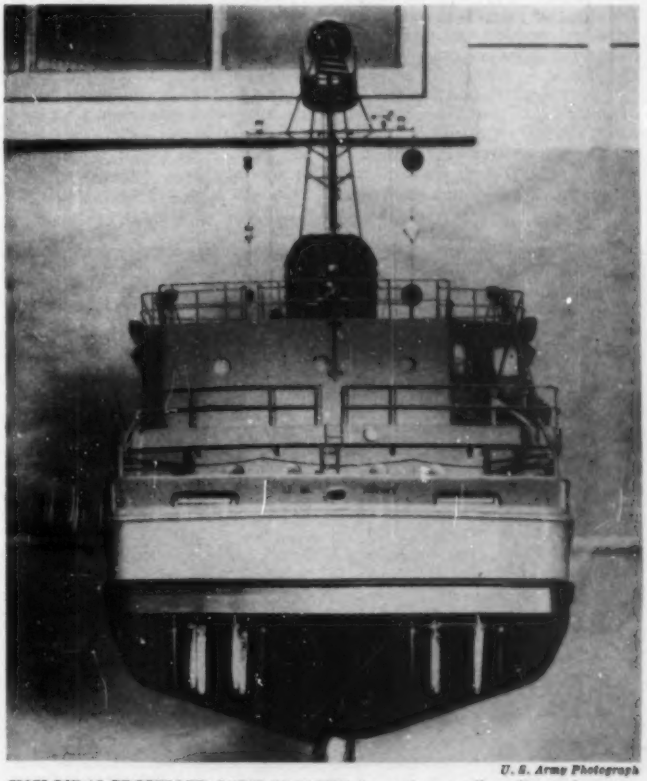
A new type of ship operated by cycloidal propellers, recently underwent a trial test conducted by the Defense Department's Transportation Board for Research and Development at Charleston, South Carolina. The mine planter *Olson* has been designed by Transportation Corps engineers not only to carry the same load as former deep-sea Army mine planters, but also to operate in shallow harbors.

The 127-foot ship is equipped with two Voith-Schneider cycloidal propellers that not only improve the vessel's maneuverability, but also do away with rudders, shaft tube, skeg and conventional steering mechanism used in screw propulsion.

The cycloidal propeller consists of a rotating disk set flush in an opening in the hull bottom. Around the periphery of this disk and perpendicular to its face are four to eight vertical blades that perform an oscillating or sculling motion about their longitudinal axis in the same fashion as an egg-beater.

In the *Olson*, there are two of these propellers located in the aft portion of the hull. They are driven by a single shaft from the engine through a right-angle gear box placed between the two propellers on the vessel's center-line.

In the pilot house two steering wheels with an interlocking device for ordinary steering are mounted. Each of the wheels is connected to two



U. S. Army Photograph

CYCLOIDAL-PROPELLED MINE PLANTER has twin propellers that replace conventional rudder, shaft tube and skeg. Ship's maneuverability is greatly improved.

shafts that, in turn, adjust the steering center of the propeller motion to the direction of thrust. When a sidewise motion is desired, the interlocking device is disengaged. To aid the sidewise motion, a control in the pilot house changes the pitch of the individual blades.

Experience and tests have proved that cycloidal propellers will be of much value not only to mine planters, but also in self-propelled lighters, towboats, ferries, floating cranes and tugboats. As a result of this concentrated effort and engineering work on the part of the Transportation Corps, commercial operators are interested in the propeller, with a view to putting it into commercial operation.

Trainer for Jet Pilots Has Twenty-Four Computors

Jet pilots will do their first flying of high-speed aircraft on the ground in the future. This "boot" training is made possible by the new "Linktronic" Trainer that simulates jet aircraft flight, and combines training for flight, engine and radio navigation in a single package.

Manufactured by Link Aviation, Incorporated, the squat, stubby assembly, which resembles a Diesel locomotive, contains all the controls, instruments and indicators of high speed aircraft. Rates of roll, climb and acceleration are faithfully duplicated with the controls loaded so that pressures vary with simulated airspeed.

An integral part of the new trainer is a series of emergency controls with which a check pilot, sitting behind the cockpit, can introduce a wide variety of operating troubles. By pushing a button the instructor can make the fuel pump or hydraulic system fail, stir up a thunderstorm, have the fuel tank punctured by a burst of flak or create any other flying hazard.

Flight conditions in the trainer can be varied from a thin overcast to night instrument conditions through the use of light-intensity controls. Wing and pitot icing are also simulated to show their effect on both flight performance and instrument indications. The new trainer also permits the introduction of rough air, its intensity being governed by the check pilot.

A series of twenty-three colored lights on the instructor's console indicate errors made by the pilot in controlling the engine. Red lights indicate an error in technique, amber lights show the result of the error and blue lights register the operating condition of the airplane. For example, if the student fails to keep the starter button pressed down long enough, a red light will show starter is "off"; a blue light will indicate the engine is "off" and the aircraft has a hot tailpipe; and, unless the pilot makes a quick correction, an amber light will register a disabled engine.

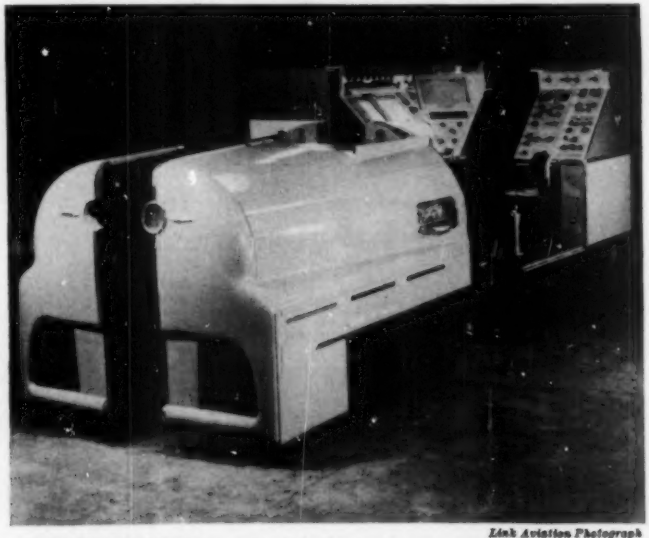
The new trainer also makes it possible, for the first time, to give the pilot instruction in the operation of very-high-frequency, omnirange and offset course computers that are coming into use. Another "first" in instrument trainers is the simulation of an infinite number of radio stations on one chart within a half-million-square-mile area.

The "brain" of the new trainer is an intricate arrangement of twenty-four electronic computers that calculate instantly the basic equations governing actions of the airplane simulated. The exact results appear on the instruments in the student's compartment.

Most interesting bit of equipment in the whole trainer is the "angelic switch". A student may have burned out his tailpipe, disabled his engine, head straight for the runway with his hydraulic system fouled, be too low for a bail-out—and still land safely. With a simple twist of the wrist, the check pilot can turn the "angelic switch" and wipe out all of the student's errors.

"Fuel consumption" of the ground-bound trainer amounts to about 6 to 7 kva of 220-v electric current per hour.

By the time student pilots have completed their training in the Jet Trainer, they will have faced almost every possible high-speed flying problem, making their first actual flights in jet aircraft seem quite ordinary. The training is expected to reduce the expensive repairs that result from errors by new pilots—and will also save many lives.



Link Aviation Photograph

JET PILOT TRAINER is constructed in four main sections, each mounted on ball-bearing casters. Quick disconnects permit rapid disassembly and reassembly.

Many German Scientists On U. S. Research Projects

Russia has not skimmed all the cream from the supply of German scientific talent for military research behind the Iron Curtain. According to the Army Information Digest, the talents of some 500 German scientists and technical experts are being utilized by the U. S. to help maintain its position of world leadership in scientific research and development.

Under this far-reaching program—known as Project Paperclip—German experts are brought to the U. S. and provided with facilities for research in electronics, supersonics, guided missiles and jet propulsion. Nearly all the technical services of the Armed Forces now are employing these scientists, and a few have been made available to civilian industry.

Hundreds of millions of dollars and

from two to ten years of research time, it is estimated, have been saved by the program. Out of the experience of the German scientists has come a knowledge of the many blind alleys to be avoided, thus narrowing the fields that remain to be explored.

Among the German scientists now working for the Armed Forces are the former director of Germany's air-to-ground and ground-to-air missiles projects; V-2 and remote control specialists; the former research directors for Junkers and Zeiss; and some of Germany's leading parachute experts and aeronautical engineers.

Typical of these scientists is Dr. Wolfgamg Finkelnburg, former professor of physics at Universities of Karlsruhe and Strasbourg. Early in the war, he was drafted into the Luftwaffe as a meteorologist. Later, released from service, he continued throughout the war as a consultant to the Air Ministry on searchlight development. Dr. Finkelnburg now lives at Fort Belvoir where he is serving as a research expert on light and radiation sources.

Among his associates at the Engineer Research and Development Laboratories, are Dr. Alexander Smakula, a specialist on optics, formerly with the Zeiss Co.; Dr. Werner K. Weihe, electronics researcher who was formerly chief of the Zeiss Electrotechnical Laboratories; and Dr. George Hass, formerly on the faculty of the Technical University of Danzig, now doing research in optics and other aspects of physics.

A total of 480 of the scientists have been recommended for immigration visas and, of these, 250 have been granted visas, as of September 1949. The privilege of bringing dependents has been granted only after months of careful observation—after it is determined beyond doubt that the scientist is not a threat to national security.

All these activities are coordinated by the Research and Development Board, under the Secretary of Defense.

Plane Runway Guide Lights Tested at Idlewild by CAA

The Civil Aeronautics Administration has put its first commercial system of slopeline approach lights into operation at New York International Airport. The lights are designed to guide planes onto the runway in bad weather or at night, and serve as a supplement to the plane's Instrument Landing System. At Idlewild, the lights are mounted on two 2,500-ft piers. They are canted so that a pilot sees two continuous strips of light when approaching at the correct angle. If the plane is off course, the pilot sees a saw-toothed pattern.

Colonel Simon Stresses Role of Research in Basic Design

THE QUOTATION BELOW is from a speech by Colonel Leslie E. Simon, Chief, Research and Development Division, U. S. Army Ordnance, who sat with a panel of government and civilian research heads at a forum on "Research and National Security". This symposium was part of the 116th meeting of the American Association for the Advancement of Science that convened recently in New York.

Colonel Simons's three-point program for increasing the fruitfulness of research endeavors not only applies to military establishments, but also is of great significance to industrial and university development groups as well.

"Let us realize for once and for all that even object-directed research can be done only in phases of fields of science that support certain classes of end products, not in the end products themselves. As a consequence of this realization, let us cease the assignment of object-classified research projects; and, instead assign to research establishments broad categories of research, or research programs. The projects (or problems) under these categories that can be undertaken at one time depend upon the competence and enthusiasm of the available scientific staff. One can look to the scientists themselves to suggest in large part the specific problems that they feel qualified to attack, and as long as the solution to a problem appears to be in support of the general field of end-products in which interest lies, the work should be approved. This liberality in work assignment is not extravagant—it is economic, because the morale and working enthusiasm engendered, the class of men attracted, and the class of men developed under such conditions make a group that can do more useful things while working only part-time on those things than a group of similar size working full-time on object-classified projects. This change in orientation of assignments is step one. step one.

"Having acquired a good research staff under step one, let us use them. The tendency has been to call on research only after the design is in grave trouble in the test stage, and after it is uneconomical to make basic changes. Under these circumstances, research must confine itself to trying to make the best thing that it can while following principles that it is too late to change. . . .

"The practically useful product of research is basic design data. Let us not demean research by assigning to it a design problem under the guise of research. Let us instead frankly ask the qualified scientists to take time off from their fundamental studies to produce a technical discussion, tabular data, and curves from which the design engineer can make intelligent choices of his design parameters. Giving research an initial place at the council table is step two in this discussion. . .

"The third step in the more effective use of research is its greater exercise in

a consultative and advisory capacity. Whereas its responsibility ceases with basic design data, research should be used to check upon design to see to it that none of its design principles are violated without good cause. Its initial participation in design makes research especially useful in giving expert help to design and development engineers.

"The three steps discussed can be summarized as understanding the role of research and giving it an appropriate place on the user-research-design-development team."

DC DOW CORNING SILICONES

Silicone News

SILASTIC* STAYS ELASTIC IN CONTACT with HOT OIL at 450°F

Performance in Aircraft Engines During Past 4 Years Proves Superiority of Silastic Gaskets

Four years ago, Pratt and Whitney started to use Silastic gaskets on aircraft engine rocker boxes. They put Silastic in contact with hot oil at operating temperatures in the range of 450°F. Proved that this Dow Corning Silicone Rubber is serviceable at temperatures far above the limits of any organic rubber.

New developments in Silastic have greatly increased its usefulness in the aircraft, automotive and electrical industries. There's Extreme Temperature Silastic, serviceable from —110° to +500°F. There are Silastic stocks with 2 to 3 times as much resistance to compression set at elevated temperatures as even the best of the earlier silicone rubbers.

Most spectacular new development is Silastic 250, the strongest and toughest rubber available for service over a temperature span of 600° from —110° to +500°F. It has greater tear resistance, 2 to 6 times the mechanical strength, 4 times the abrasion resistance of the best silicone rubbers previously available.

Photo courtesy Pratt and Whitney Aircraft

Phone our nearest branch office or write today for data sheet No. AC-142.

DC Silicone Insulation Saves $17,415.00!

Dow Chemical Company engineers increased pumping capacity by having 12 of these 50 and 60 h.p. motors rewound with Dow Corning Silicone (Class H) Insulation. List price for new 75 h.p. Class A motors, $24,840. Rewinding cost only $7,425. They saved $17,415 and got Class H motors able to withstand frequent peak loads of 86.5 h.p. as proved by recording ammeter chart shown above.

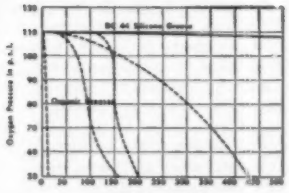
For more power per pound, greater overload protection, more reliable service and longer life, phone our nearest branch office or write for data sheet No. AC-146.

Photo courtesy The Dow Chemical Company

FURTHER PROOF OF THE PERMANENCE OF DC 44 SILICONE GREASE

Oxygen bomb tests indicate freedom from gumming and confirm usefulness of DC 44 Silicone Grease as a life-time lubricant for permanently sealed ball bearings. Consulting engineers who made these tests for us used equipment that meets Norma-Hoffman specifications.

A sample of DC 44 Silicone Grease was placed in contact with a polished brass disc which served as an oxidation catalyst. The sample was then exposed to oxygen under a pressure of 110 p.s.i. at 210°F. After 504 hours, pressure in the bomb had gone down only 1.5 pounds. Contrast such remarkable resistance to oxidation with that of even the most stable organic greases tested under the same conditions.



Comparative oxidation resistance of DC 44 Silicone Grease and various organic greases as indicated by changes in oxygen pressure with increasing time at 210°F.

Combine such oxidation resistance with a bleed of 1% and evaporation of only 3.5% compared with evaporation of 15 to 40% for high temperature petroleum greases after 24 hours at 390°F. and you have specifications for a really permanent lubricant.

These data as well as the lubricating properties of DC 44 Silicone Grease are confirmed by practical experience including performance in the 'cartridge' type bearings of an entire line of industrial motors. For more data on Dow Corning Silicone Grease, write today for data sheet AC-14C.

*T. M. Reg. U.S. Pat. Off.

First in Silicones

DOW CORNING CORPORATION, MIDLAND, MICHIGAN

ATLANTA • CHICAGO • CLEVELAND • DALLAS • LOS ANGELES • NEW YORK

In Canada: Fiberglas Canada, Ltd., Toronto • In Great Britain: Albright and Wilson, Ltd., London

Dow Corning FIRST IN SILICONES

Deflections of Rubber Compression Sandwiches

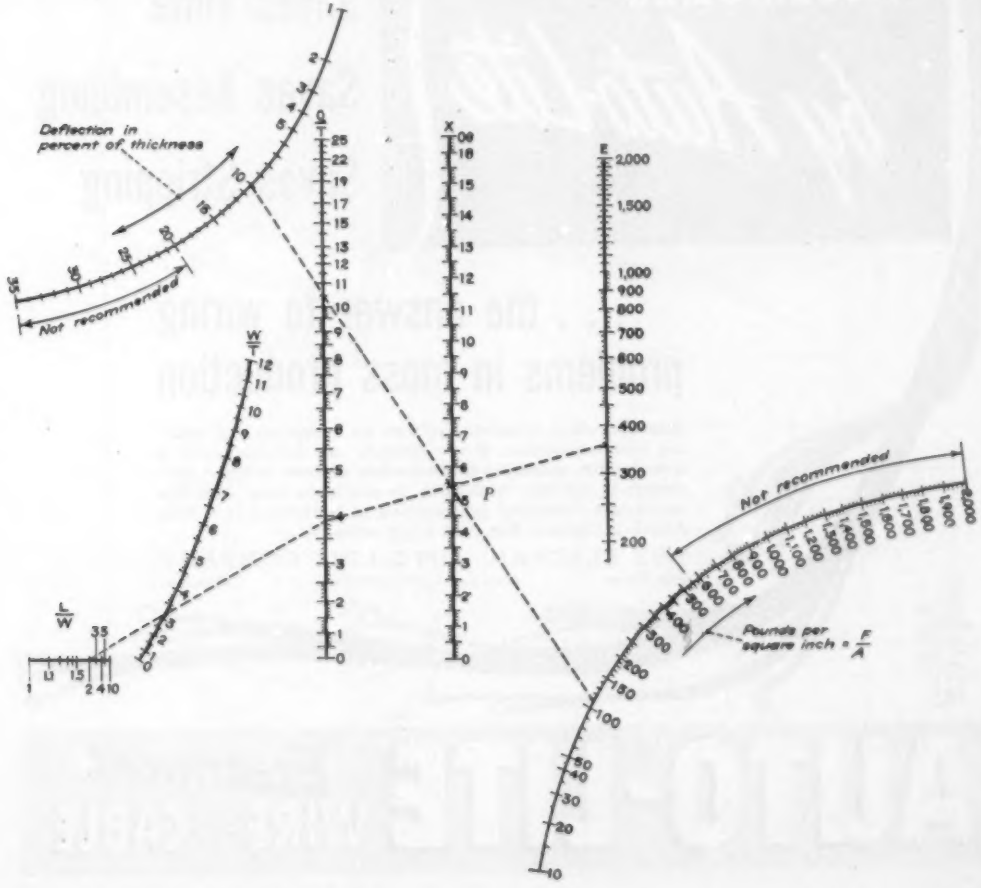
U. S. RUBBER COMPANY

THE DEFLECTION for a given average pressure can be calculated from given values of average compression modulus E and ratio of effective width to thickness Q/T. Except for rectangular sandwiches, values of Q/T can be determined from the formulas and charts of the following page. To calculate deflection, connect the given points of the (Q/T)- and E-scales with a straight line, intersecting the x-scale. The line connecting that intersection with the given point of the (F/A)-scale will intersect the relative deflection scale at the required point. This data applies to adhered rubber only.

EXAMPLE: Given $Q/T = 3.9$, $E = 360$ psi, $F/A = 110$ psi. Connect 3.9 on the (Q/T)-scale and 360 psi on the E-scale with a straight line intersecting the x-scale at the point P. Connect P with 110 psi on the (F/A)-scale with a straight line. Extend this line and read the value 10 percent on the relative deformation scale.

FOR a rectangular sandwich, the value of Q/T is calculated from the values of L, W and T directly from the nomogram. Connect the values of L/W and W/T by a straight line. The extension of that line intersects the (Q/T)-scale at the correct value of Q/T.

EXAMPLE: Given $L/W = 2.0$, $W/T = 3.2$. Connect 2.0 on the (L/W)-scale with 3.2 on the (W/T)-scale. The extension of this line intersects the (Q/T)-scale at 3.9.



WIRING HARNESS ASSEMBLIES *by Auto-Lite*

Saves Measuring
Saves Cutting
Saves Fitting
Saves Time
Saves Assembling
Saves Stripping

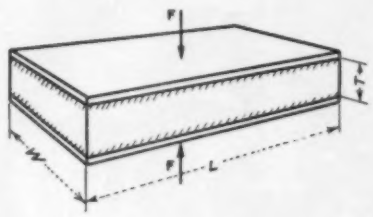
. . . the answer to wiring problems in mass production

Auto-Lite offers complete facilities for designing and building wire assemblies. If you already use harness, send a sample with quantities and schedule desired. When a new design is needed, assistance is available from Auto-Lite engineers. Detailed information is contained in a free Auto-Lite Catalog. For your copy, write to

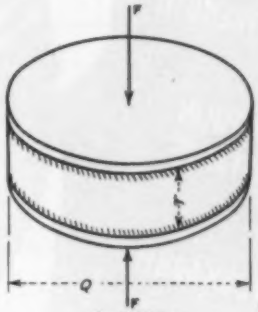
THE ELECTRIC AUTO-LITE COMPANY
Port Huron *Wire and Cable Division* Michigan

AUTO-LITE ELECTRICAL WIRE and CABLE

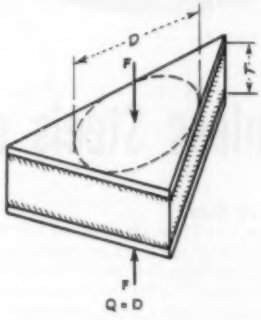
Deflections of Rubber Compression Sandwiches (continued)



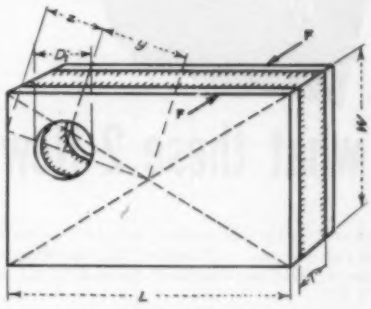
See nomogram on preceding page



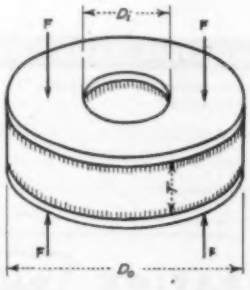
$Q = 0.93D$



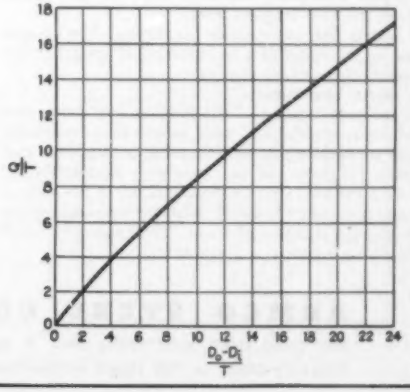
$Q = D$



$$Q = Q_{\text{(no hole)}} - \frac{W}{L}\left(\frac{z}{z+y}\right)D_i$$



See chart



This anti-shimmy damper, machined from Armco 17-4 PH bars, is one of 13 production parts on the AJ-1 and B-45 airplanes in which this special stainless steel is now used.

See what these 2 New Stainless Steels offer you

All these advantages for your products are *combined for the first time* in two new grades of stainless steels developed by Armco Research. They are known as Armco 17-7 PH and Armco 17-4 PH.

Until now, stainless steels that could be heat-treated to high strengths and hardnesses had certain fabricating and service limitations. Armco's new "PH" grades offer you the excellent mechanical properties of the hardenable chromium types, *plus workability and corrosion resistance* closely approaching the 18-8 stainless steels.

"PH" stands for precipitation hardening. The unique properties are the result of a combination of special chemical compositions and heat treatments.

17-7 PH SHEETS AND WIRE

Now you can have Armco 17-7 PH Stainless Steel sheets that draw and form readily, and with simple heat treatments reach yield strengths up to 160,000 psi in both tension and compression. Hardness can be brought to Rockwell C45.

With 17-7 PH wire you get a combination of the highest elastic properties and corrosion resistance ever offered by any high strength stainless steel wire. Yield strengths range up to 340,000 psi after heat treatment.

17-4 PH BARS

Armco 17-4 PH is ideal for bar fabrication and forgings. It *may be finish-machined* and then heat-treated to obtain the desired hardness. You needn't worry about cracking, scaling, or distortion. The low-temperature (850-900° F.) heat treatment causes only a slight discoloration which can be easily removed without affecting the dimensions of precision machined parts.

Get *all* the facts about Armco 17-7 PH or Armco 17-4 PH bearing on your specific problems.

MAIL THIS HANDY COUPON NOW

Send me complete data on ☐ Armco 17-7 PH; ☐ Armco 17-4 PH.
We manufacture .....

Name_____ **Title**_____

Company_____

Street Address:_____

City_____ **Zone**____ **State**_____

ARMCO STEEL CORPORATION

2050 CURTIS STREET, MIDDLETOWN, OHIO • PLANTS AND SALES OFFICES FROM COAST TO COAST • THE ARMCO INTERNATIONAL CORPORATION, WORLD-WIDE

Extent of Flange Stress Concentration Region

IT IS DESIRABLE to locate stress raisers in flanged parts out of the region of flange stress concentration. The actual boundaries of such a region are undefined and depend upon the extent to which high stresses can be tolerated. Furthermore, there are locations where the stresses are reduced as a result of the flange.

In Fig. 1 is shown a flange and pipe combination. The outside diameter of the pipe is $2R_o$ and the inside diameter is $2R_i$. The thickness of the pipe is b. The mean diameter is $2R = 2R_i + b$. The distance of a cross-section from the edge of the flange is x. The area of the pipe cross-section is A and Poisson's ratio for the material is μ.

The stress in the pipe due to the external load F is given by the formula:

$$S = S_f + \frac{F}{A} \qquad (1)$$

The term S_f depends upon the distance x. Its maximum value S_{fm} occurs when $x = 0$. Values of S_f/S_{fm} are plotted against x times a constant designated as β, which is given by the formula:

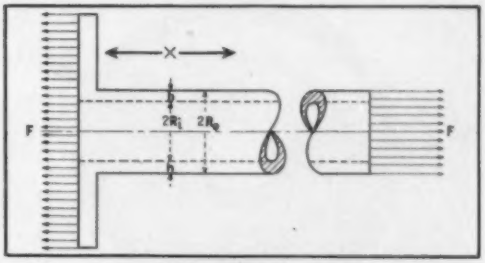
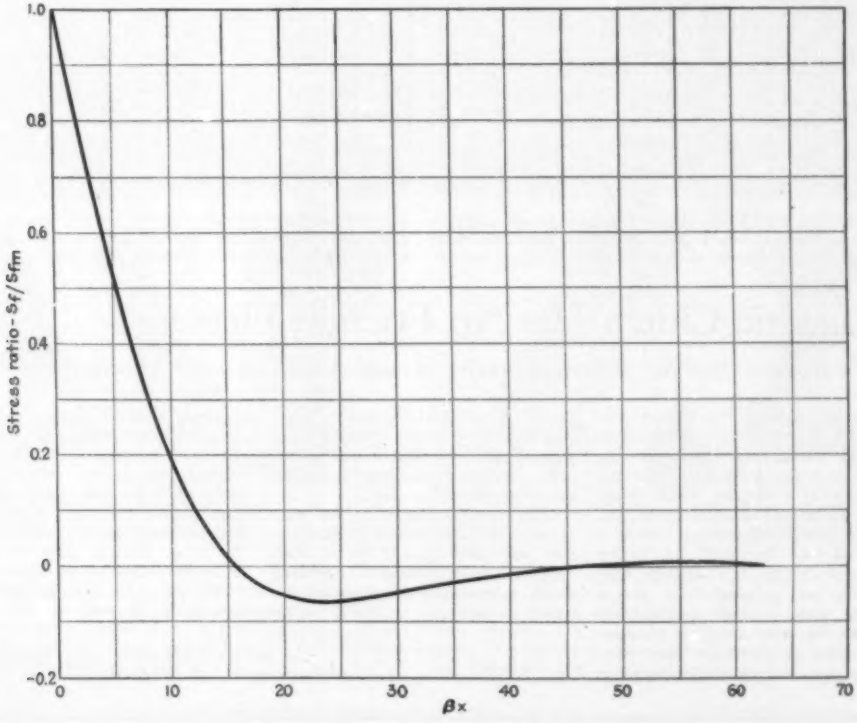
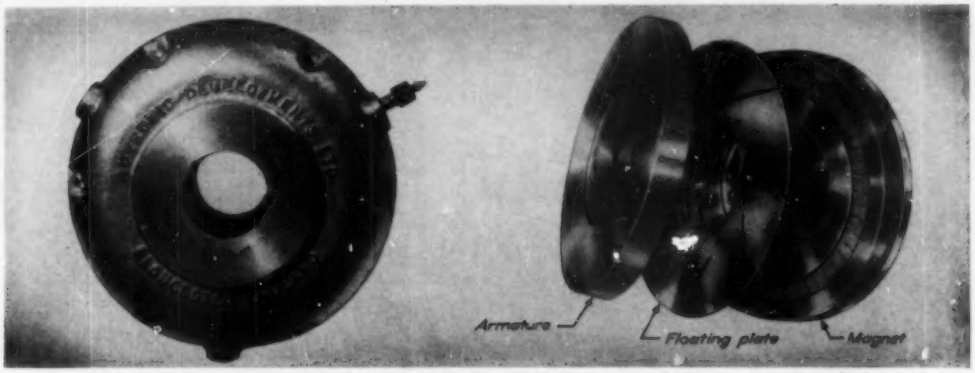


Fig. 1—Pipe and flange subjected to the axial force F.

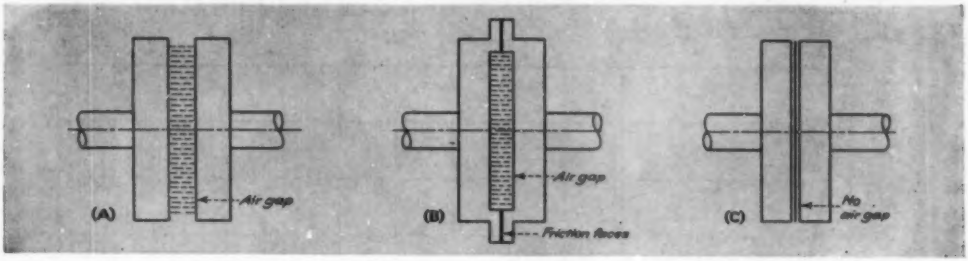
$$\beta = 10 \sqrt[4]{\frac{3\,(1-\mu^2)}{R^2 b^2}}$$

From the chart, it can be seen that in the immediate vicinity of the flange, the stress raiser would have a much more detrimental effect than at a location where $\beta x = 25$.





CLUTCH has only three moving parts. Floating plate moves in oil bath to lubricate working faces, and enables flux lines to pass through shortest possible distance. It is an easy replacement in case of wear.



SCHEMATIC DRAWING show principles of all magnetic clutches. Type A, with a large air gap, is extremely weak. Type B employs friction surfaces to increase torque but air gap still weakens flux and friction surfaces wear and need adjustment. Type C, the "Autronic", has no air gap and no friction surface to wear. Floating plate runs in oil bath.

Magnetic Clutch Has No Friction Element

Torque comes from the resistance to bending of magnetic flux and not from friction surfaces.

Featuring a basic, three-element design, this magnetic unit is produced as a straight forward starting and driving clutch, a brake, a combined driving clutch, or as a slipping clutch safety device to prevent overloading on any kind of power transmission system.

Called the "Autronic", this device has a disk magnet and armature with hardened and polished faces, and a floating plate of high permeability between the two working surfaces. Since there are only these three component parts in each single unit there are no adjustments to be made. Torque is proportional to the current passing through the unit; thus infinitely variable control is available by the simple use of resistance switches.

One big advantage is in the space saving. A clutch unit 6 in. in diameter only takes up 1¾ in. of shaft length. An "Autronic" reversing clutch, or combined driving clutch and brake, is only 2¾ in. thick. Since torque is the result of electro-magnetic adhesion, and does not rely on friction, it is independent of speed. This characteristic is the reverse of the standard types of electro-magnetic clutches where torque falls rapidly with increased speed. Sizes from 2 to 30 in. in diameter give torques up to 7,000 ft-lbs, or 45 brake hp at 3,000 rpm. Any voltage from 24 to 240 dc can be used.

Autronic Developments, Ltd., Gloucester, Eng.
New York Representative, 240 East 61 St., New York 21, N. Y.

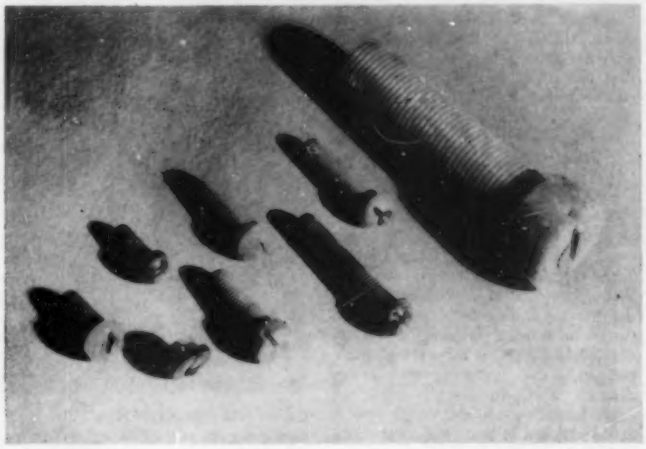
Insulated Screw Simplifies Electrical Design

Metal core gives strength and rigidity to plastic screw.

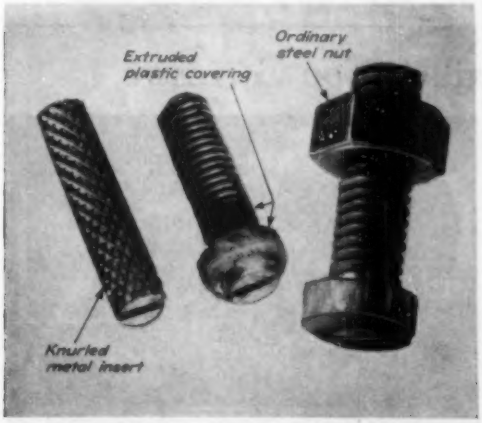
In making this insulated screw a metal core is first knurled and a plastic covering then extruded around the core. The piece is then screw-machine finished to form the head and threaded section. The plastic portion of the head is not subject to strain because the metal core carries the torque of the driving tool.

The most important use will be in the assembly of electrical components. The screw eliminates the need for insulating washers and jackets and allows the designer to simplify many cumbersome constructions that have formerly been necessary. The screw also insulates against heat and chemical action, and acts as a damper for vibrations. Any size and head style, and any kind or size of threads may be obtained on special order. A great variety of colors are available.

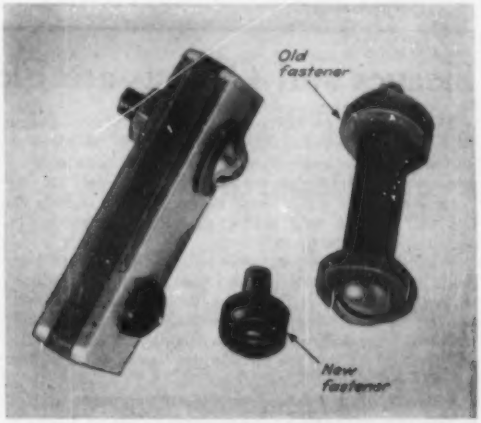
Foreman Insulating Screw Corp., 401 Broadway, New York 13, N. Y.



A VARIETY of sizes and head shapes are shown. Cores may be brass, steel, aluminum, or any other metal. Any type or color of extrudable plastic may be used.



CONSTRUCTION is simple and strong. Knurled core has plastic covering extruded around it. There is a strong bond between core and covering. Dielectric strength of insulating core depends upon type of plastic and wall thickness. Plastic threads also have a natural locking property that eliminates need of lock washers and sealing gaskets.



TYPICAL APPLICATION shows how the new screw simplifies construction. The old fastener, with 5 parts, is shown at right. One insulated screw does the same job in less time, with a better appearance, a saving in space, and plenty of holding power. The small core shown here allows the necessary plastic wall thickness to give high dielectric strength.

CONTINUED ON PAGE 160

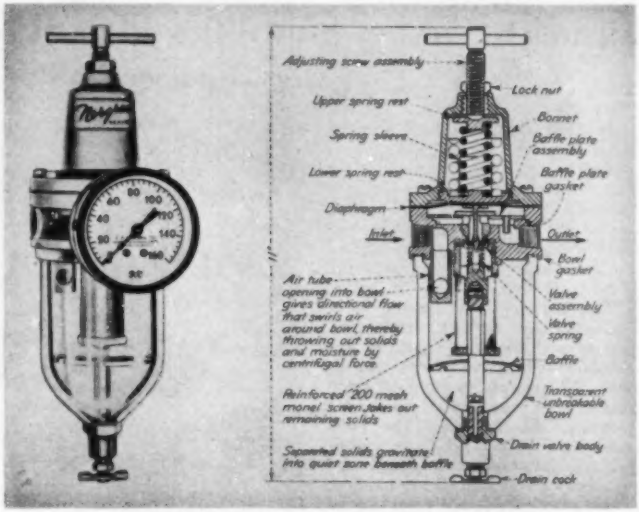
Filter-Regulator Combined in One Compact Unit

Serves both as filter and pressure regulator for use with air or any non-corrosive gas at pressures up to 125 psi and ambient temperatures up to 120 deg F.

Recommended as original equipment on all types of production machines and for spray painting lines, instrument control and other industrial air line use. Separation is accomplished by both centrifugal action and screening, as explained by the illustration. Because the screen has a surface area ten times that of the pipe openings, even with a considerable portion of the screen clogged, the remaining openings present a far greater area than that of the pipe openings. Hence air velocity through screen is low, filtering efficiency is high and screen need not be cleaned as frequently.

The combination of baffle plate, swirling action and large filter screen area, gives this filter regulator a larger airflow capacity with less pressure drop than other regulators with equal sized diaphragms and ports. It will respond faster to sudden demands for large volume of air or gas supply, and without excessive momentary pressure drops. With an overall height of only elevent inches, the entire unit is easily installed in line pipe connections and can be readily dismantled.

C. A. Norgren Co., 222 Santa Fe Drive, Denver 9, Colo.



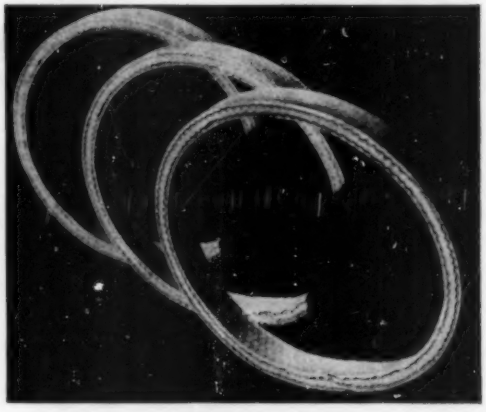
INLET AIR TUBE OPENING directs the air so as to cause a swirling action. Moisture and entrained solids are thereby thrown against the wall of the bowl by centrifugal force, drop through the baffle and into the quiet zone beneath it. Particles that are not separated out by centrifugal force are caught by the screen of reinforced 200-mesh monel wire, which has a surface area ten times that of pipe opening.

Sleeves and Gaskets are Flexible, Non-Corrosive

Development of a new process which facilitates bonding of Silicone rubber and Fiberglas by means of mandrel-curing to produce sleeves and gaskets has been recently announced. The new sleeves are available in sizes ranging from $\frac{1}{4}$-in. inside dia to those having a $5\frac{1}{2}$-in. outside dia and wall thickness ranging from $\frac{1}{16}$ to 1 in. Sleeves can be supplied in lengths up to 3 feet.

Prior bonds of Silicone rubber and Fiberglas have been made by means of sheet lamination and strengths produced in this manner only increased the tear resistance. Mandrel-bonded Silicone rubber and Fiberglas sleeves and gaskets now have increased strength both laterally and horizontally, and they are suitable for installations involving high pressures as well as high temperatures.

Flexible Silicone rubber sleeves are recommended for applications requiring the transmission of hot or corrosive gases, and super-cooled liquids at temperatures ranging from —110 to more than 400 degrees Fahrenheit. In addition, they will not crack, become brittle and will not deteriorate after long exposure to air, ultra violet rays and ozone. Excellent dielectric properties of Silicone make it particularly applicable for electrical installations.



The Stalwart Rubber Co., 166 Northfield Rd., Bedford, Ohio

CONTINUED ON PAGE 162

3 WILL GET YOU 4

...WITH N-A-X HIGH-TENSILE STEEL

MAKE A TON OF SHEET STEEL GO FARTHER
Specify—
N-A-X
HIGH-TENSILE STEEL

It's a fact. It's demonstrated every day, in the production of varied parts and products. *Three tons* of N-A-X HIGH-TENSILE steel are yielding as many finished units as were yielded formerly by *four tons* of carbon sheet steel!

This "new arithmetic in steel" is in step with industry's trend to the use of improved steels. When cold-rolled steel was found to be preferable to hot-rolled for many uses, industry substituted cold-rolled for hot in these uses. Today, it is equally logical and economical to replace simple carbon sheets with low-alloy high-tensile.

N-A-X HIGH-TENSILE makes it possible to reduce sections by 25% ... and *still provide* greater strength and durability than can be obtained with thicker sections of mild-carbon steel! Each ton of N-A-X HIGH-TENSILE steel represents a potential 33% increase in finished goods. Manufacturers are finding that N-A-X HIGH-TENSILE enables them to get 33% greater usefulness out of steel supplies.

Investigate this great opportunity to make each ton of sheet steel go farther ... through the superior quality of N-A-X HIGH-TENSILE.

GREAT LAKES STEEL
Corporation

N-A-X Alloy Division, Ecorse, Detroit 29, Mich.
UNIT OF NATIONAL STEEL CORPORATION

Two Pressure Solenoid Air Valve Saves Compressed Air

Two inlet ports allow full line pressure for work stroke of air cylinder and low pressure for return stroke.

This 4-way, 3-port, two pressure, solenoid operated air valve effects a real saving in compressed air when used with a double acting cylinder. High or low pressure can be applied to either inlet port, and pressures can be reversed at the option of the operator. Pressure range is from 20 to 150 psi. The valve is available in $\frac{3}{8}$ and $\frac{1}{4}$ in. pipe sizes.

Whether reduced pressure is applied to the cylinder work stroke or to the return will depend on the results required. In many applications it is imperative that a controlled low pressure be used on the work stroke, with higher pressure used to return the piston rapidly. Usually, however, full advantage is taken of maximum air pressure available to keep cylinder diameter at a minimum. The exhaust port may be restricted, when desired, to reduce cylinder piston speeds.

Mechanical Air Controls, Inc., 3049 E. Grand Blvd., Detroit 2, Mich.

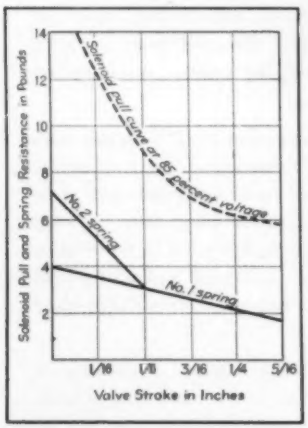
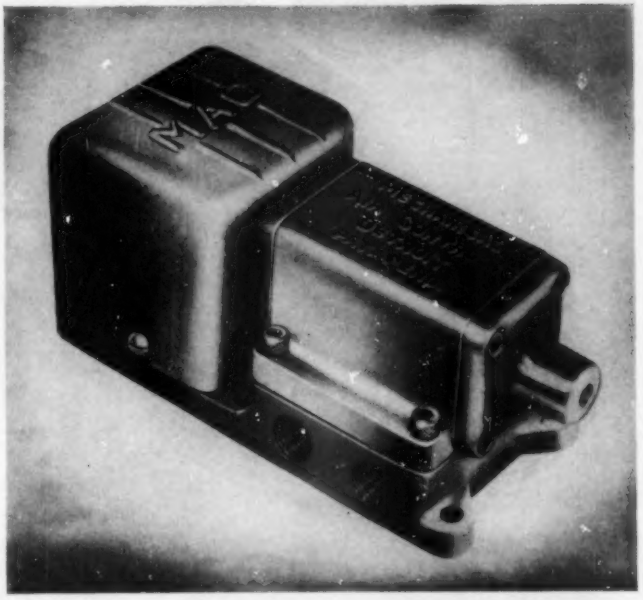
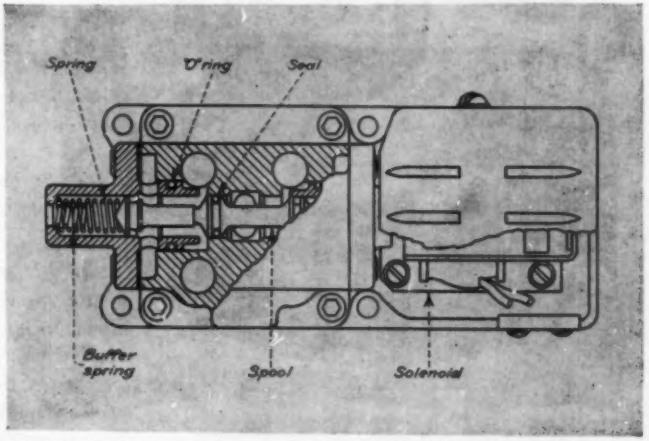


CHART for the $\frac{1}{4}$ in. valve shows the relation of the solenoid pull curve at 85 percent voltage to the corresponding load build-up of the two springs. Note that the initial spring rate is well within the pull of the solenoid, offering a minimum of resistance, and when the solenoid pull curve rises sharply, the second spring checks the impact of the plunger, as well as insuring positive return of the valve spool. Drawing at right shows springs.



EASILY SERVICED, this air valve has only one moving part, and it (the spool) may be removed by taking out 4 screws. Solenoid and wiring are also accessible.



ALL AIR PASSAGE HOLES are drilled, thus eliminating complex blind coring. Solenoid plunger is applied directly to the light-weight spool for fast action. All internal diameters which contact the moving seals are diamond bored, honed, polished, hard chrome plated, and repolished to insure smooth operation.

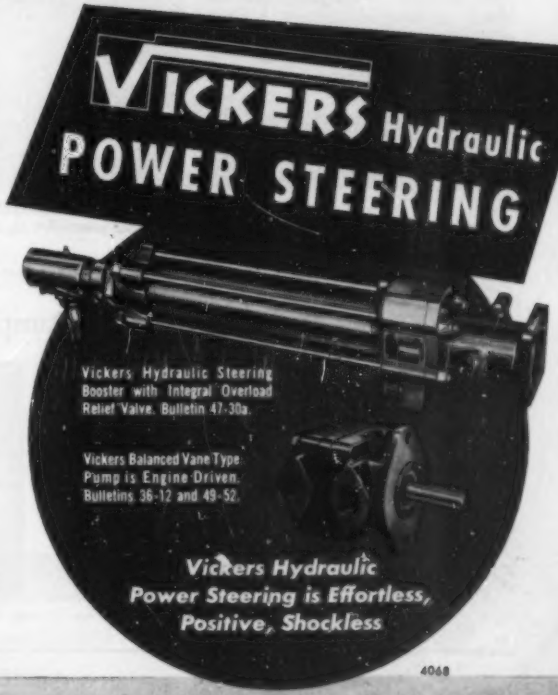
CONTINUED ON PAGE 164

Safe Steering in Emergencies *with*

When forced off the road onto rutted, soft, rocky or snow-banked shoulders, your driver will be grateful for Vickers Hydraulic Power Steering. The steering mechanism is then hydraulically locked against road condition reaction . . . the vehicle cannot swerve from road reaction. There is no "wheel fight" to wrench the steering wheel out of the driver's hands. Pull back onto the road requires only the "force of a finger" on the steering wheel.

Vickers Hydraulic Power Steering is safer . . . effortless . . . provides hydraulic power at instant command of the driver to meet any and all steering requirements. This extra-quick steering greatly increases the ability to maneuver in an emergency. Another important advantage . . . the driver is less tired, more alert.

Vickers Hydraulic Power Steering can be used as original equipment, or adapted to most trucks and other vehicles now in service. Write for Bulletins 47-30 and 49-52 covering additional advantages and specifications.


VICKERS Hydraulic
POWER STEERING
Vickers Hydraulic Steering Booster with Integral Overload Relief Valve. Bulletin 47-30a.
Vickers Balanced Vane Type Pump is Engine-Driven. Bulletins 36-12 and 49-52.
Vickers Hydraulic Power Steering is Effortless, Positive, Shockless
4068

VICKERS Incorporated
DIVISION OF SPERRY CORPORATION
1454 OAKMAN BLVD. • DETROIT 32, MICH.

Application Engineering Offices: ATLANTA • CHICAGO • CINCINNATI • CLEVELAND DETROIT • HOUSTON • LOS ANGELES (Metropolitan) • MILWAUKEE • NEW YORK (Metropolitan) • PHILADELPHIA • PITTSBURGH • ROCHESTER • ROCKFORD ST. LOUIS • SEATTLE • TULSA • WASHINGTON • WORCESTER

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

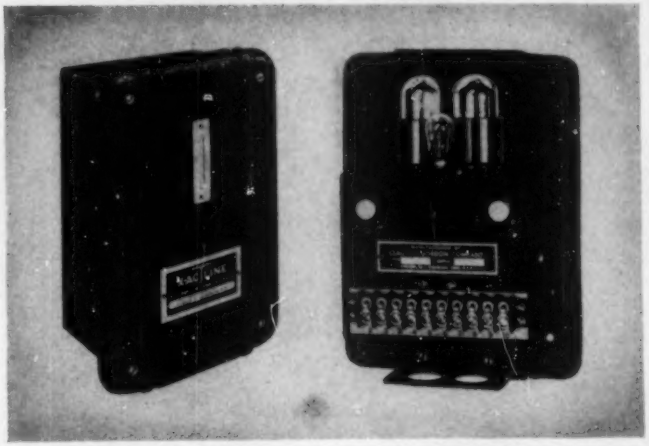
Temperature Control Unit Anticipates Change

In conventional pyrometer installations the temperature control point must be passed in one direction or the other before any control action takes place. This means a constant fluctuation in temperature. The "Xactline" instrument has two anticipator tubes to catch the smallest temperature variation and act to control it before any control point has been reached. The temperature chart shows a perfectly straight line when the new unit is in operation.

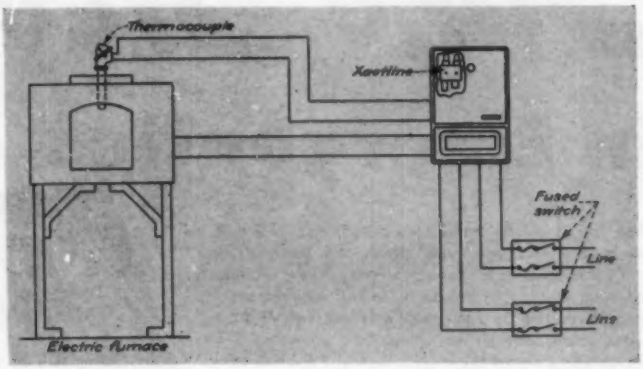
The "Xactline" anticipator tubes have two miniature thermo-couples and a small heating element. The only moving part in the instrument is a small, two-position relay. The operation is entirely electric, there are no mechanical parts to cause time lag.

The instrument is applicable to all types of electric furnaces, ovens, injection molding machines, and other equipment employing conventional millivoltmeter and potentiometer type controlling pyrometers, or gas fired equipment employing solenoid-controlled or motor-operated valves. The case is 8¼ in. high, 6¼ in. wide, and 3 in. deep, and is made for wall mounting or flush mounting in cabinets or panels.

Claud S. Gordon Co., 3000 South Wallace Street, Chicago 16, Ill.



FRONT AND REAR views show simplicity of design. Action is entirely electric. There are no mechanical parts to cause time lag and introduce inaccuracy.

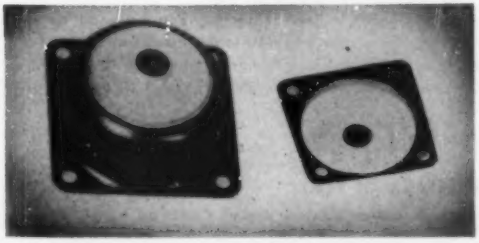


TYPICAL INSTALLATION shows the Xactline used with a standard millivoltmeter pyrometer controller to give "straight-line" control in a small production furnace.

Mountings Permit Vibration Damping at Extreme Temperatures

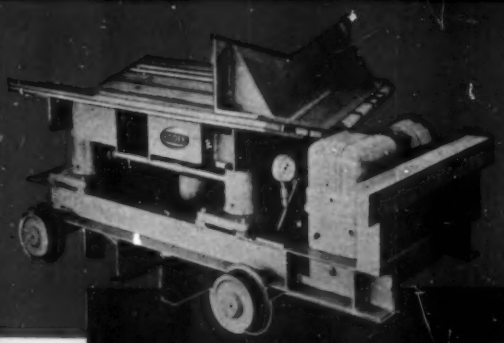
Vibration mountings made with silicone rubber will carry their designed loads and absorb disturbing frequencies within the temperature range of — 100 to + 500 deg F.

This new "Cohrlastic" mounting is made in the standard AN instrument series sizes, and can be made in special sizes when the application requires it. The mounting is of the so-called plate type, and works on the rubber-in-shear principle. The low temperature characteristics are important for high-flying aircraft applications, and the high temperature characteristics will allow many industrial applications.

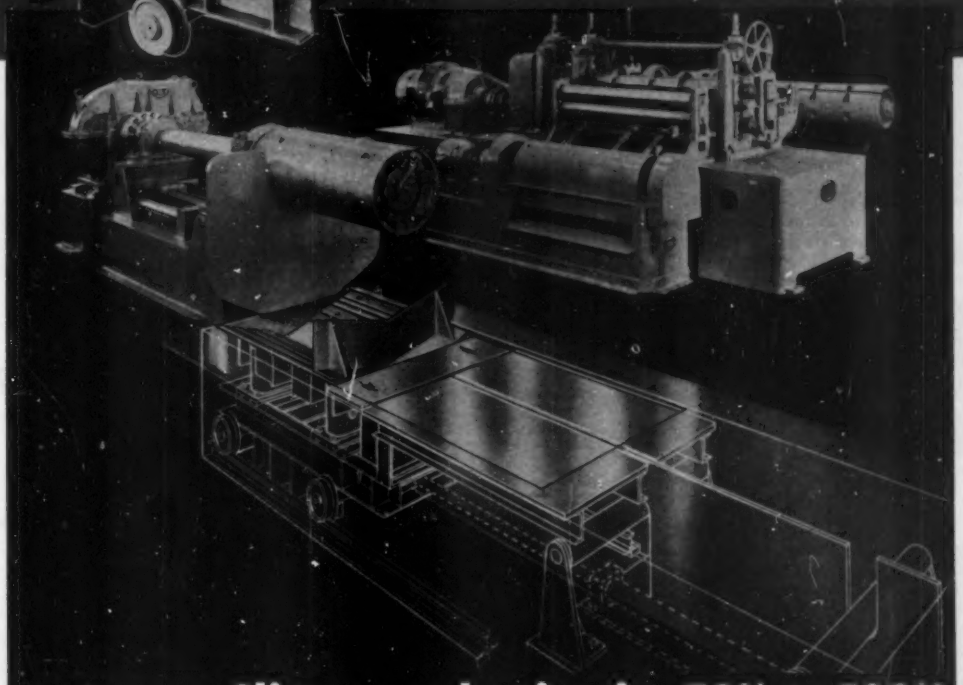


The Connecticut Hard Rubber Co., 407 East St., New Haven 9, Conn.

CONTINUED ON PAGE 166



YODER COIL CARS



—step up Slitter production by 50% to 100%

Where greater slitter production is needed, instead of buying a new slitting line, you may be much better off by installing one or two Yoder Hydraulic Coil Cars of the latest, most efficient design. By saving time in loading the Uncoiler, unloading the Recoiler, and doing the banding elsewhere in the shop, coil cars are often the most economical means of increasing production and reducing cost.

Typically, 16 minutes per coil often spent on the operations just mentioned may be reduced to two or three minutes, reducing the cycle time from 25% to 50%.

The use of Coil Cars and other means of saving time and money in slitter operations are discussed in the new Yoder 76-page book on Slitting Lines and their Operation—yours for the asking.

Whether your requirements in slit strands are small or large, you will find the time studies and other information in this book of more than ordinary interest.

THE YODER COMPANY
5324 Walworth Avenue • Cleveland 2, Ohio

Complete Production Lines

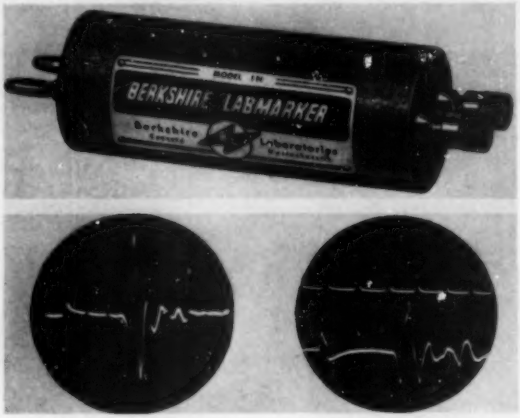
- ★ COLD-ROLL-FORMING and auxiliary machinery
- ★ GANG SLITTING LINES for Coils and Sheets
- ★ PIPE and TUBE MILLS—cold forming and welding

ENGINEERING YODER MANUFACTURING

New Wave Shaping Device Available

The Berkshire Labmarker is essentially a wave shaping device used to produce time marks in cathode ray oscillography. A sinusoidal input voltage (Maximum amplitude 30 rms) is converted by the Labmarker into a series of sharp unidirectional pulses. These pulses may be displayed directly on the face of a cathode ray tube by connecting the output of the Labmarker to the vertical input. Timing marks consisting of short breaks in the oscillograph trace are obtained by connecting the output of the Labmarker to the "Z" input terminals of the oscilloscope. Both of these timing methods are shown in the photographs.

This compact self-contained unit may be plugged into the terminals of an audio frequency oscillator. No other power source is required. The output binding posts of the Labmarker may be used with leads having single or double banana plugs, spade tips, phone tips, or plain wire ends. Two types of instruments are available, the Model 1N, giving negative pips; and the Model 1P, giving positive pips.



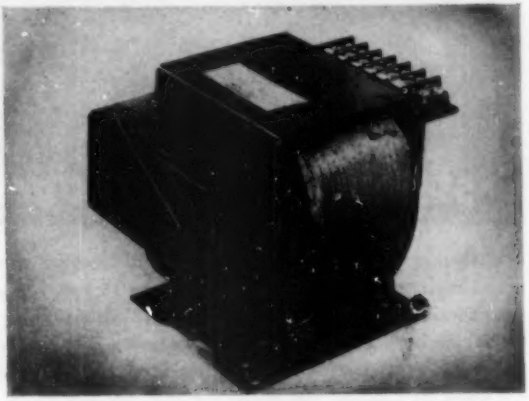
Berkshire Laboratories, P.O. Box 70K, Concord Mass.

Transformers Are for Machine Tool Control

Particularly adapted to the inductive, low-power factor loads of solenoids, relays, and contactors making up machine tool control equipment, the secondary voltage of these 60-cycle transformers remains above 90 percent of rated voltage up to a load current of 7 times normal at 20 percent load power factor.

Seven sizes from 0.075 to 1.5 kva are available for 220/440 primary to 110 secondary at 60 cycles. Transformers for 50-cycle operation are available in six sizes ranging from 0.150 to 1.5 kva for 208/220/380/416/440 primary to 110/95 secondary. Three sizes from 0.150 to 0.500 kva are available for 25-cycle operation at 220/440/550 primary to 110 secondary.

Size and weight of the new transformers one-half kva and larger are especially low because of the use of type "C" "Hipersil" cores. Use of this grain-oriented magnetic steel reduces size and weight.



Westinghouse Electric Corp., 306 Fourth Ave., Pittsburgh 30, Pa.

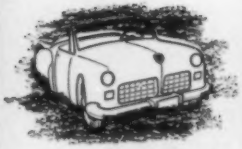
Pressure Gage Has Illuminated Dial Gage

Made in a square case for flush mounting on a panel, this gage has a black dial background and ultraviolet phosporescent pointer, numerals, and graduations. It is made in standard 4½, 6 and 8½ in. dial sizes with the same drilling dimensions as conventional round case gages.

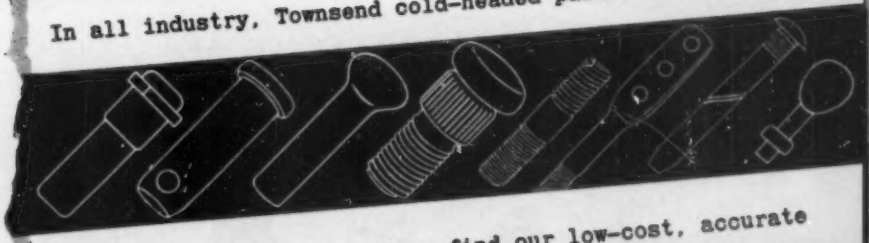
This gage has the following features: The Helicoid Movement, which means there are no teeth to wear out; stainless steel bearings, fused joints, Korex steel Bourdon tubes, and the external pointer adjuster. Plain white illumination can be supplied.

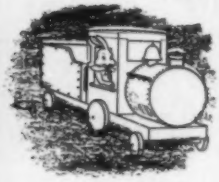
Helicoid Gage Div. of American Chain & Cable Co., Inc., Bridgeport 2, Conn.

CONTINUED ON PAGE 168

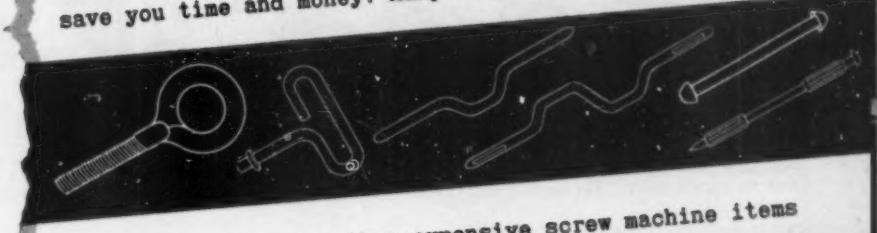


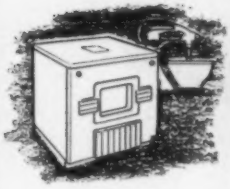
In all industry, Townsend cold-headed parts and fasteners



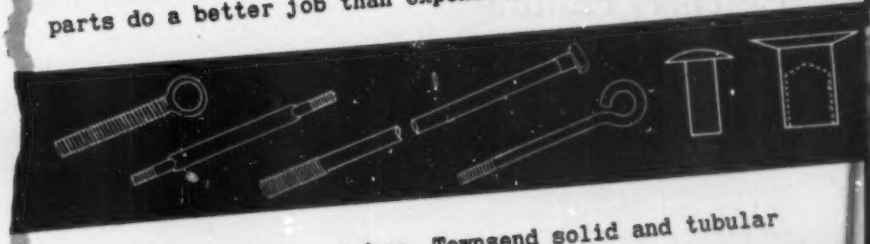


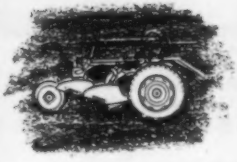
save you time and money. Many find our low-cost, accurate



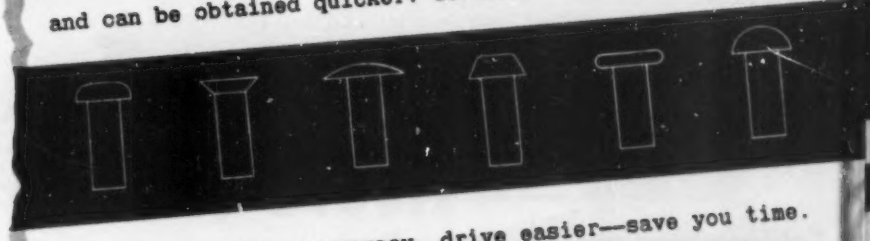


parts do a better job than expensive screw machine items

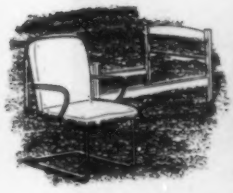


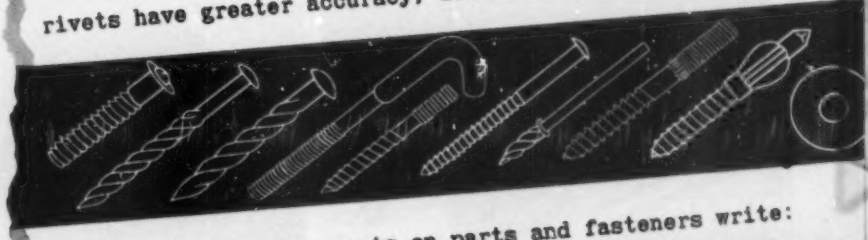


and can be obtained quicker. Townsend solid and tubular



rivets have greater accuracy, drive easier—save you time.



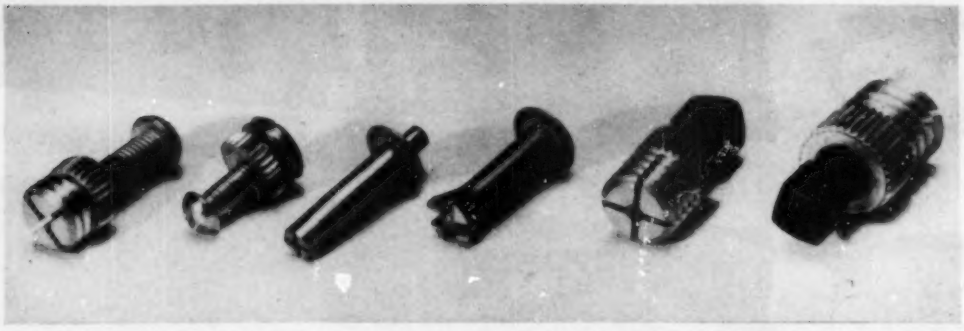


For help in reducing costs on parts and fasteners write:

Townsend

COMPANY — ESTABLISHED 1816

New Brighton, Pa.
Chicago 38, Ill.



ANCHOR NUTS, (left and right) provide a permanent receptacle for machine screws. The machine screws shown above are used to expand serrations. Blind rivets, (center) are expanded with one hammer blow. No special tools or skills are needed.

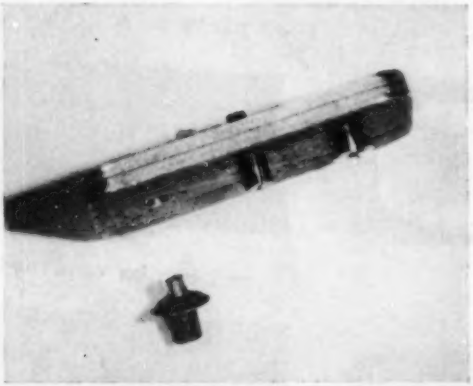
Fasteners Feature Quick Assembly, High Holding Power

Working on the principle of the expansion of serrated segments, both the blind rivet and anchor nut may be quickly installed without the use of special tools or skills. One blow of a hammer will drive in the pin and expand the segments of the blind rivet—an ordinary machine screw will seat the anchor nut firmly in either wood, plywood, or metal faced plywood.

The blind rivet is available with brazier, modified brazier, button, round, and countersunk head styles, and in shank sizes from $\frac{3}{16}$ to $\frac{1}{4}$ inch. Special size and styles can be made on special orders.

The anchor nuts are stocked in sizes from 6–40 to $\frac{5}{16}$–24, and are also available with National Coarse threads.

South Chester Corp., Finance Bldg., Philadelphia 2, Pa.



BLIND RIVET is pushed into place and the pin driven down flush with the head. The expanded end pulls up metal to form a tight joint. Once the right length of rivet has been determined there is no chance of incomplete take up.

INSTALLATION of anchor nut is simple. First, drill a clean hole; drive in nut; and expand with a machine screw. Nut is then permanently fixed in place.

ILLUSTRATING two of the many types of heads available, this illustration shows two rivets joining sheet metal and plywood. Simplicity and strong take-up are important features.

CONTINUED ON PAGE 170

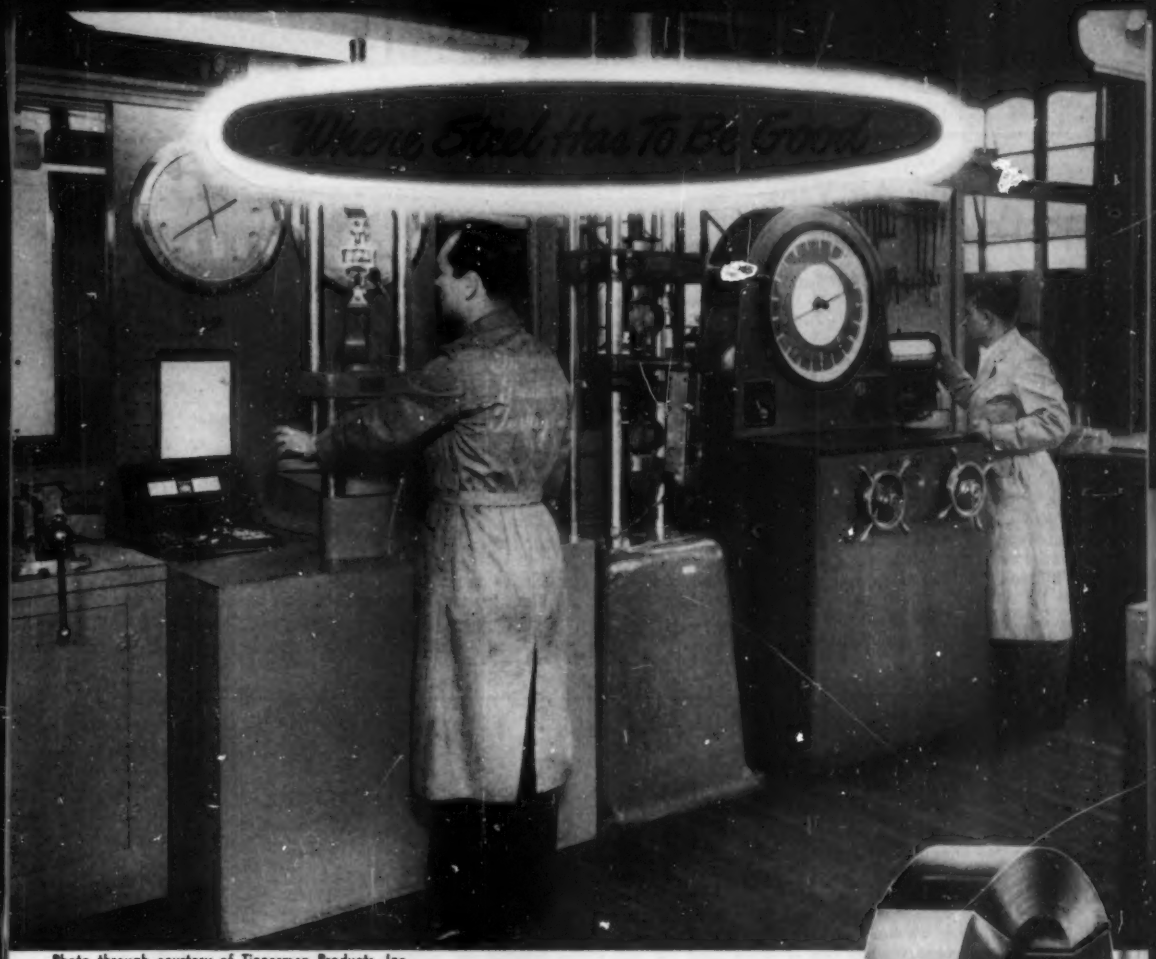


Photo through courtesy of Tinnerman Products, Inc.

Sharon Quality Steels *Meet Every Test!*

Where the operation demands steel of exacting properties many manufacturers have learned to rely on Sharon High Quality Steel 100 percent.

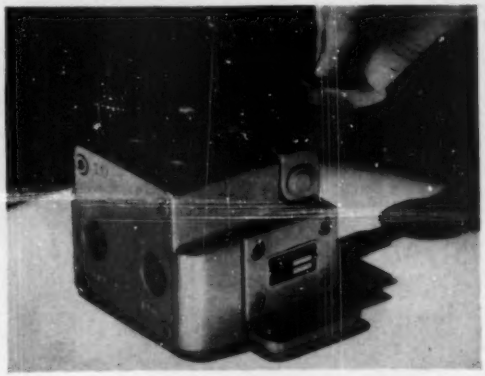
These manufacturers, who frequently maintain expensive testing laboratories such as the one pictured above, find Sharon quality consistent —coil after coil—month after month.

If your operation requires the **best in steel consistently**—call Sharon—a great name in steel for almost half a century. Offices listed below appear in classified section of phone directory.

SHARON STEEL CORPORATION

Sharon, Pennsylvania

Fast Cycling Air Valve Is Hand Controlled



A new, fast cycling type of hand operated valve which provides 4-way directional air control provides what approximates "pushbutton" control with physical effort reduced to a minimum.

Light hand pressure depresses the control knob $\frac{3}{8}$ in. to operate the valve. Air line pressure, acting through a pilot control connected to the control knob lever, supplies the force to move the piston operated main valve. Valve action is almost instantaneous, thereby permitting faster operating cycles with less loss of time in operating a valve.

Designated Model NHS, the valve features a reciprocating, packless, self-lapping main valve disc. A light compression spring raises the control knob when the hand is removed. The valve is now available in $\frac{1}{2}$ in. and $\frac{3}{4}$ in. sizes for use with air line pressures of from 25 to 150 lbs. "In" and "out" air line connections are located in the top of the valve with pipe connections to air cylinder in the back. Where it is desirable to provide remote control or simplify piping connections, the control knob can be located on the end of an extended rod connected to the operating lever. The valve, itself, can be mounted in any position that keeps the valve piston in a horizontal plane.

Hannifin Corp., 1126 South Kilbourn Ave., Chicago 24, Ill.

Potentiometer Adds Or Subtracts Two Variables

Type 748 Differential Computing potentiometer is made primarily for applications requiring the addition or subtraction of two variables in a single unit, with one voltage source. Uses include servomechanisms for computing or power amplification, and the direct replacement of two single potentiometers when one is being used for compensation or correction purposes.

The specifications are: body dia, 3.093 in.; flange dia, 3.718 in., guaranteed accuracy, $\pm$ 0.1 percent; maximum overall resistance ($\pm$10 percent), 150,000 ohms; electrical angle rotation, 354.5 deg ($\pm$0.5 deg); mechanical rotation, continuous; power dissipation, 5 watts; torque, 1 inch ounce, maximum; and life service, over 1,000,000 cycles.

This dual unit, through coin-silver precision slip rings in the cover plate, will produce a net voltage sum or difference when one variable rotates the shaft, while the other rotates the body of the potentiometer.

Fairchild Camera and Instrument Corp., 88-06 Van Wyck Blvd., Jamaica 1, N. Y.

Pipe Plugs Have "Breather Vent"

Made for use with transmissions, gear reduction units, and other such applications, these U. S. Breather Vent plugs have a center of sintered porous bronze metal. This core of porous metal allows closed housings to "breathe" without allowing entrance of foreign materials. Another advantage of the plug is the prevention of gasket blowout under excessive pressures. These plugs are interchangeable with any other standard pipe threaded plug. They are made in pipe thread sizes of $\frac{1}{8}$ to 4 in., inclusive, and have standard square or counter-sunk heads.

U. S. Plug & Fitting Co., 305 Frederick Bldg., Cleveland 15, Ohio

CONTINUED ON PAGE 172

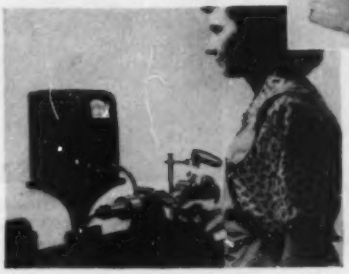
ELECTRONIC MEASURING EQUIPMENT

This equipment provides a reliable means for taking external and internal measurements with precision and ease that advance accurate manufacture and size control. By a simple turn of graduation selector, tolerances can be checked from "tenths" to "hundredths".

Exclusive advantages: any graduation value between .0001" and .00001" . . . separate amplifier completely isolates heat-producing elements . . . true linear response of amplifier permits accurate setting for entire scale with only 1 gage block . . . amplifier may serve several separate testing instruments.

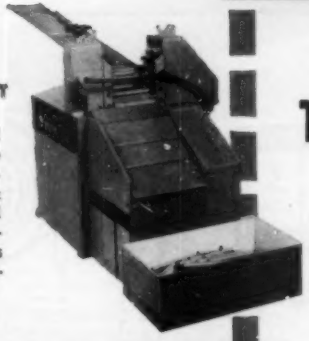
External comparator with range of 0-4". Simplified setting. One master only. Reversible anvil. Self-checking. Shock-protected. Diamond gaging point.

Internal comparator attachment for use with external comparator and amplifier . . . range ½" to 2". Frictionless. No parts to wear. Only only one master.



Gage head cartridge for mounting in jigs, fixtures or similar testing pieces. Measurement range .002". Frictionless. Dust and moisture proof.

ELECTRONIC INSPECTION AND SORTING EQUIPMENT



Unique design . . . manual loading and disposal to fully automatic . . . custom-engineered at Brown & Sharpe to meet individual requirements. Simplification of parts and functions makes machines more compact, more dependable.

JOHANSSON GAGE BLOCKS

. . . world famous both for their extreme accuracy and for their fast-growing importance to manufacturing of interchangeable parts. These precision aids to quality control are made by Brown & Sharpe; from single blocks to complete sets and useful accessories. Jo-Blocks have hundreds of cost-saving uses.

Take your cost cutting cue from this *QUALITY CONTROL EQUIPMENT*

With any one of these modern quality control devices you can lay the foundation for an efficient, cost-cutting quality control program. Each device offers thoroughly proven features that broaden the advantages of quality control. All reflect the high precision standards associated with the Brown & Sharpe name. For complete details write Brown & Sharpe Mfg. Co., Providence 1, R. I., U. S. A.

We urge buying through the Distributor

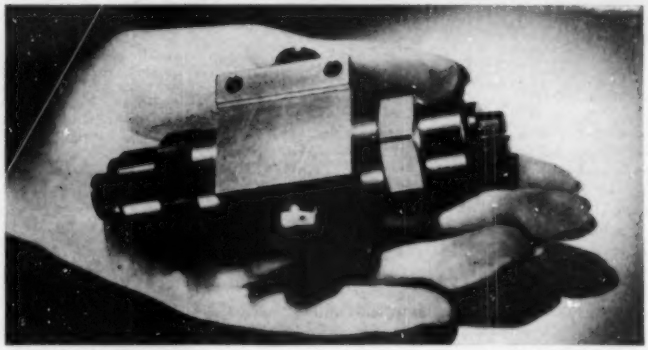
BROWN & SHARPE

Shuttle Valve Handles 3,000 Psi

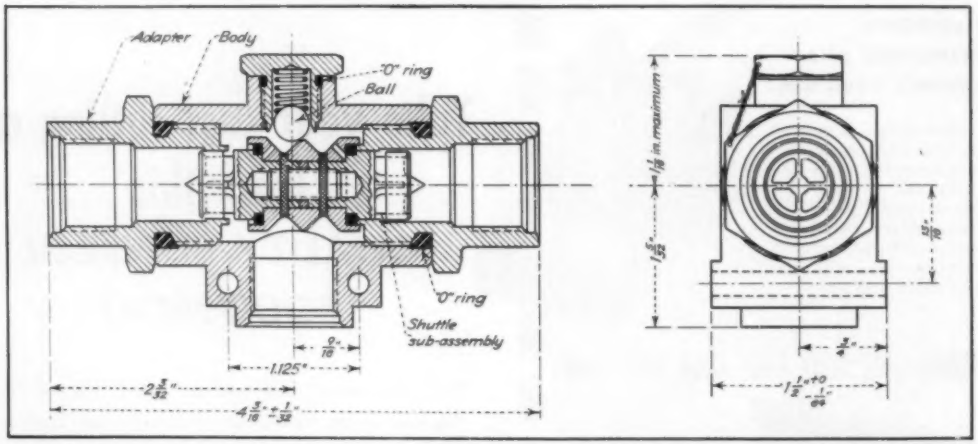
Produced primarily for aircraft use, this shuttle valve also has industrial applications where it is desired to supply alternate pressure sources to a cylinder or other device as precaution against emergency or for other design reasons. It is made in tube sizes 6 and 8, which have outside tube diameters of $\frac{3}{8}$ and $\frac{1}{2}$ in., respectively.

The valve will shuttle against a closed line. The shuttle will not unseat from surge flows or negative pressures. Surge flows will not displace the synthetic rubber seat. Showing no evidence of deformation or failure at burst test pressures of 7500 psi, the valves have a pressure drop of less than 10 psi at rated flow.

The Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio



UNDER TEST, this valve shows zero leakage of static pressures of 3,000 psi or proof pressure of 4,500 psi, and zero leakage while shuttling under air or oil pressure. Pressure drop is less than 10 psi at rated flow.



DESIGNED according to AN specifications, this valve will shuttle against a closed line. The shuttle will not unseat from surge flows or negative pressures, and surges will not displace the synthetic rubber seat. Valves are made in 6 and 8 tube sizes.

Radio Tubes Are Made for Rough Usage

Five types of radio tubes specially designed to provide dependable communications service under conditions of severe vibration and shock have been recently announced.

These five types of tubes, include 6X5WGT a full wave rectifier; 6L6WGA, a beam power amplifier; 28D7W, a double beam amplifier; 6SL7W, a high-mu duotriode; and 6SN7W, a medium-mu duotriode.

Electrical characteristics and circuit applications of these tubes are similar to corresponding standard types but physical design of tube structures has been modified to give dependable service life in conditions of unusual shock and vibration. The tubes are part of a "Ruggedized" line, and have been redesigned with much shorter "fatter" shapes that will stand high accelerations without tipping over.

Sylvania Electric Products, Inc., 500 Fifth Avenue, New York 18, New York

CONTINUED ON PAGE 174

MEASURE YOUR PRESENT MOLDING POWDER AGAINST NEW PLEXENE TA

for Strength—
Stability—
Easy Molding

This Shuffleboard T-Square of PLEXENE TA *stays straight—has high impact strength. Molded by the Emeloid Co., Inc., Hillside, N. J.*

PLEXENE TA is the remarkable new Rohm & Haas thermoplastic molding powder that offers unusual possibilities in the injection molding field. It combines easy molding with high impact strength. Low water absorption and complete absence of chemical plasticizers give exceptionally good dimensional stability. Low flow temperature and "flat" plasticity curve assure excellent moldability. And in the bargain, PLEXENE TA offers good chemical and electrical properties; easy finishing, machining and cementing; good heat stability.

For the molding of rugged, durable business machine and radio housings, battery cases, steering wheels, tool handles, gun stocks and casings of all kinds, get the full story of PLEXENE TA now. Send for our new folder and technical literature on this unique thermoplastic molding powder.

Send for your free copies today.

CHEMICALS FOR INDUSTRY

ROHM & HAAS COMPANY

WASHINGTON SQUARE, PHILADELPHIA 5, PA.

Representatives in principal foreign countries

PLEXENE *is a trade-mark, Reg. U. S. Pat. Off. and in principal foreign countries.*

Canadian Distributor: Crystal Glass & Plastics, Ltd.
282 St. Helens Avenue, Toronto, Ont.

New Thermosetting Adhesive Does Not Shrink or Swell

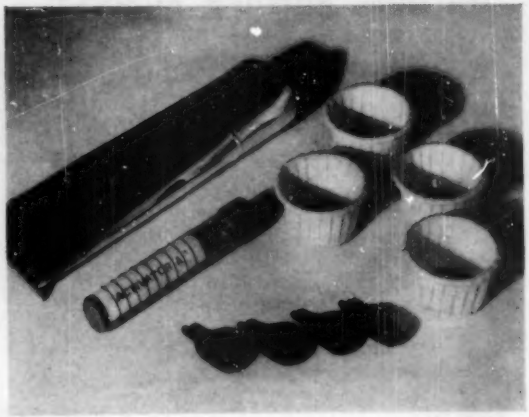
This unique thermosetting resin adhesive contains no volatile solvent and does not shrink or swell upon hardening. The entire composition sets up to a rigid solid and becomes the adhesive bond between the materials to which it is applied.

The new A-1 adhesive will bond a large variety of materials, including metals, glass, ceramics, rigid plastics, wood and rubber. Since it contains no volatile solvent it can be used as a gap-filling material, and materials to be bonded together may be assembled immediately after application of the adhesive.

The adhesive is supplied in two parts; a reddish brown resin composition and a liquid activator which are mixed together immediately prior to use. Two liquid activators are available, one a fast reacting type which results in a rapid initial set (and a short pot life of 20-30 minutes), the other a slower reacting type (with a pot life of 4 to 5 hours).

Proper use demands clean surfaces to which the mixed adhesive is applied. The surfaces to be bonded are coated with the adhesive, brought together and held with pressure sufficient to maintain uniform contact. The resulting bond is strong, moisture and weather resistant, and permanent.

Armstrong Products Co., Argonne Road, Warsaw, Ind.

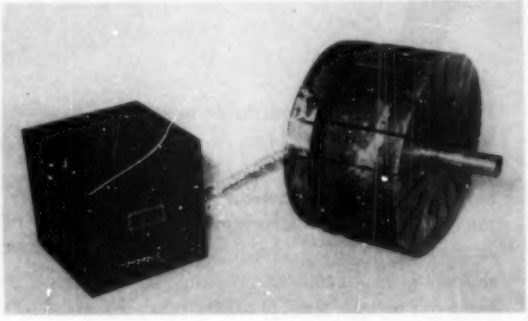


SAMPLE KIT shows three constituents. Large tube contains reddish-brown base. Activator "A" is for fast curing, and activator "B", in capsules, for slower curing. Rapid cures are made at 200 deg F. Temperatures above this are not recommended. Room temperature provides a normal full strength cure in about one week.

Electric Unit Takes Place of Air Cylinder

Designed for the same type of service now being done by air and hydraulic cylinders, these "Electro-thrust" units are capable of applying pressures up to several tons. For operations requiring pressure, impact, or impact followed by pressure, these units offer strokes of a fraction of an inch up to several inches in length. They are made of cylindrical cast electrical steel, and are easily mounted. The Model illustrated is 9 in. in diameter, 5 in. long, and develops a maximum pressure of 6,000 lb. Other sizes are available on order to meet specific customer requirements. These thrust units operate through a special control and can be used with standard ac lighting current.

Black and Webster, Inc., Needham, Mass.



Counter Made for Incorporation on Original Equipment

The new "CS" counter is especially designed for incorporating on original equipment, such as Machine Tools, Textile Machinery, Farm Machinery, Measuring Machinery and Office Machinery. A top-reading rotary model, this counter features large-size figures for clear legibility and an integral case made of a single die casting, giving the counter great rigidity, a tight seal of working parts, and smoothness of appearance.

Both reset and non-reset models are stocked in four-figure cases; and five and six-figure sizes are available. The counter has a flush mounted window to assure good visibility. It is furnished for either clockwise or anti-clockwise rotation in standard 1:1 or special ratios; has a speed of 600 rpm, and a finish of grey wrinkle enamel.

Durant Mfg. Co., 1938 N. Buffum St., Milwaukee 1, Wis.

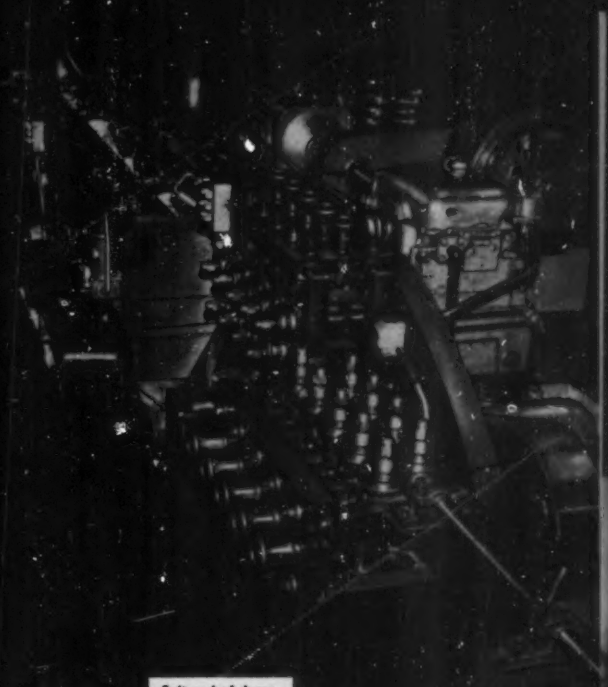
CONTINUED ON PAGE 176

Amazing Lomatic Doubles and Triples Past Output

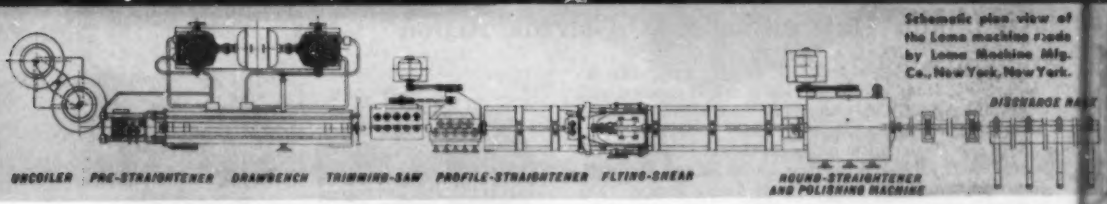
EMPLOYS

OILGEAR

AT CRUCIAL POINTS



Exit end of drawbench showing the twin Oilgear Fluid Power Pumps.



Schematic plan view of the Loma machine made by Loma Machine Mfg. Co., New York, New York.

AN unusual type of rod-processing machine produces finished stock at a rate two to three times faster than on conventional drawbenches or other types of continuous drawbenches.* Drawing, straightening, shearing and polishing of brass rod are done in one operation on these Oilgear-equipped Lomatic machines.

Oilgear variable delivery pumps, cylinders and valves operate feed roll clamp to start rod through the pre-straightener. The Oilgear equipment provides synchronized operation in tandem and high-speed alternate drop-back in the draw carriage cycle. These functions are crucial to the successful operation of the Lomatic. The wonderfully smooth and steady drawing speed gained from Oilgear equipment means the production of uniformly high quality stock. The operator has full manual control of his machine for set-up and test purposes. He has remote pushbutton control of each carriage . . . and full automatic continuous operation. These superiorities result from the Oilgear simplified fluid power and control system.

Here is another outstanding achievement in machine design where Oilgear Fluid Power plays an important role in enabling the designer and builder to gain the requisite flexibility of application and control of power, simplicity of construction, engineering and installation, sturdiness, and built-in protection against overload.

You can do things with *this* power you *CAN'T* do with any other power . . . and you can do them *BETTER* with Oilgear Fluid Power equipment. What is your problem? Write THE OILGEAR COMPANY, 1571 W. Pierce Street, Milwaukee 4, Wisconsin.

*See article "Brass Rods" published in THE IRON AGE, April 14, 1949.

See Sweet's 1950 File for Product Designers, Section 4C/6.

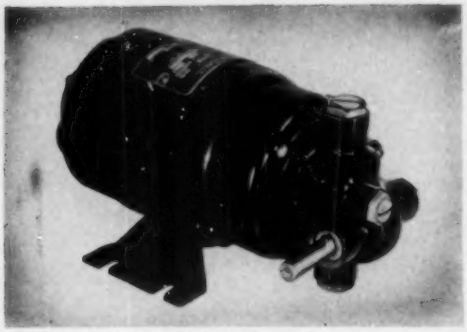
Oilgear

PIONEERS IN FLUID POWER

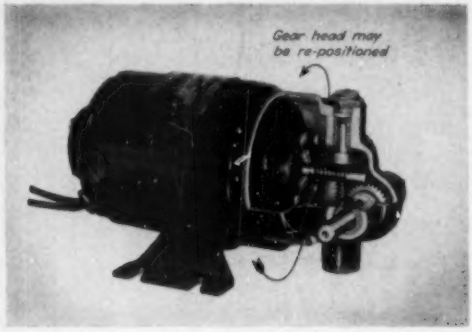
Pumps, Motors, Transmissions, Cylinders, and Valves

Small Gear-Head Motors Have Wide Power and Speed Ranges

New line offered in either single or double reduction models.



OUTPUT SPEEDS ranging from 833 to 8 rpm, and torques from 1 to 500 in. lbs, give these gear head motors a wide variety of applications ranging from animated displays to timing devices or conveyor drives. Ratings vary from 1/200 to 1/3 hp, with reduction ratios from 6:1 to 900:1. Motors are now being built in Universal, Shaded Pole, and dc motor types, both single and double reduction units.



COUNTERSHAFT can be positioned in increments of 30 or 90 deg relative to a horizontal center line by relocating the gear head on the frame. The motor can also be furnished for reversible operation. The worm wheels are made of either bronze or Bakelite. The advantages of high speed motor performance plus the economies of standardization and compact design are important features.

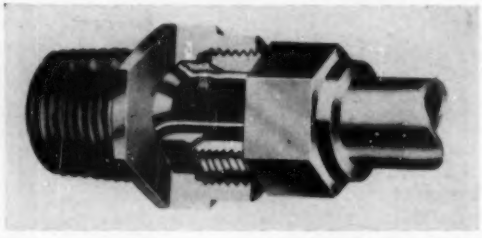
Robbins & Myers, Inc., Springfield, Ohio

Aluminum Tube Fitting Stops Galvanic Action

Made for use with annealed aluminum tubing, these fittings do not cause the galvanic action that is common with brass fittings used with aluminum. Consequently, there is no corrosion and weakening of the seal.

This new all-aluminum fitting has the same "uniflare" design as used by the same company's brass fittings. It is self-contained, two-piece, and has a self flaring feature. The body of the fitting contains a thrust collar. One turn of the nut, with an ordinary wrench, is sufficient to shear off the collar, and further tightening clamps the collar onto the tube to form a tight seal.

Advantages pointed out by the manufacturer are, in addition to the convenience of the self-flaring feature and the leak proof seal: no danger of the tube cracking during flaring, and the opportunity to use standard wall tubing rather than the much heavier tubing often required to provide extra strength. These fittings are available in all standard shapes on a made-to-order basis for use with aluminum tubing 3/16 through ½ in. outside diameter.



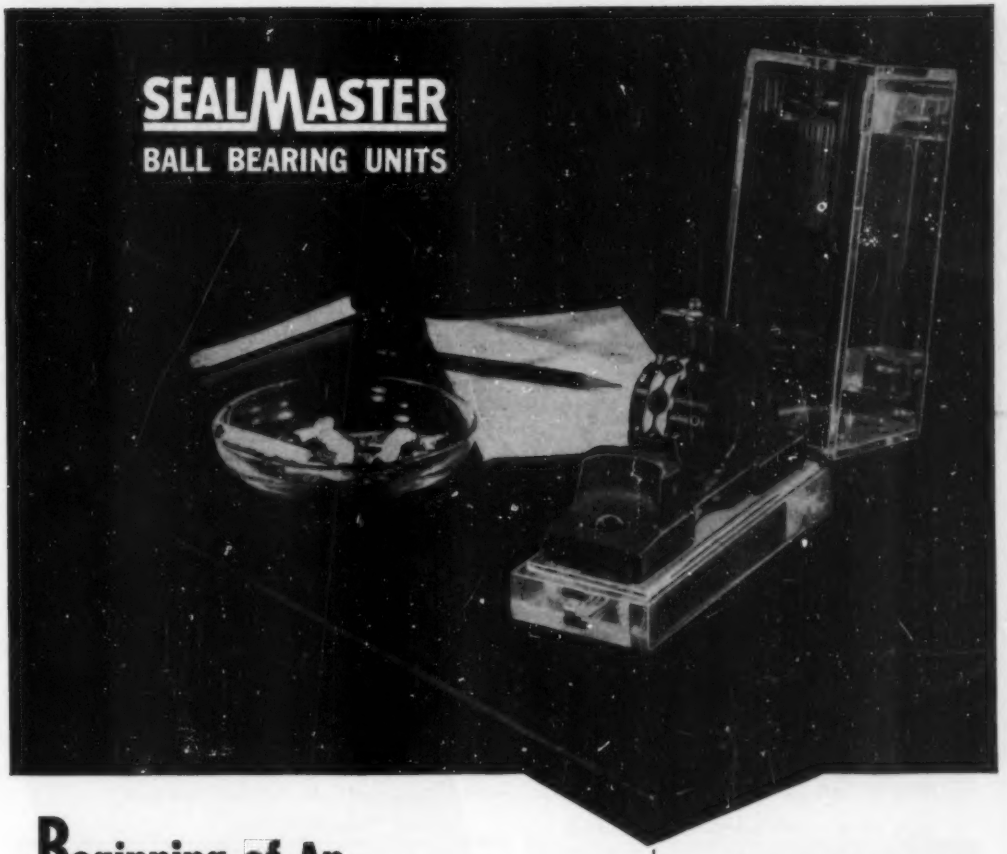
Scovill Mfg. Co., Waterbury, Conn.

Temperature Indicating Pellets Available in Higher Ratings

These temperature indicating pellets melt when they reach their rated temperature to provide positive visual indication. They are now made in higher ratings to indicate 2,100, 2,200, 2,300, 2,400, and 2,500 deg F temperatures. The complete line now starts at 113 deg F, and goes up by steps of 12½ deg to a rating of 400 deg. From 400 to 2,000 deg the steps are 50 deg, and in 100 deg steps to 2,500 F. A crayon form of indicator has corresponding intervals from 113 to 2,000 deg. The paint form is available in ratings from 113 to 1,600 deg F. only.

Tempil Corp., 132 West 42nd Street, N. Y. 11, N. Y.

CONTINUED ON PAGE 178



Beginning of An Important Product Improvement

No machine can be better than its bearings! Bearings are basic . . . to long life, to dependability . . . to the performance and reputation of the product. In the product planning stage be sure to investigate the advantages that SEALMASTERS exclusive combination of features can give to your product.

It's no accident that a great many of the foremost machine manufacturers are specifying SEALMASTER Ball Bearing Units. Pillow Block (shown above), Cartridge, Flange, Flange-Cartridge, Take-Up and Hanger Units, as well as many special types, are illustrated in the SEALMASTER catalog. Have your secretary write for it today.

Bearing Division
STEPHEN S-A DAMSON
MFG. CO.
9 Ridgeway Avenue, Aurora, Illinois — Los Angeles, Calif. • Belleville, Ontario

5 Reasons Why You're Better Off with SEALMASTERS

1. **Permanently Sealed**
Felt-lined steel flinger rotating in labyrinth, prevents entry of dirt and retains proper amount of lubricant.

2. **Self-Aligning!**
Bearing unit, with seals independent of the housing, can align itself in any direction without seal distortion.

3. **Prelubricated**
The bearing chamber is filled with the proper amount of grease before bearing leaves factory.

4. **No Housing Wear!**
Patented locking pin and dimple prevent rotation of outer race in housing, thus eliminating housing wear . . . permit shaft alignment and position unit for relubrication.

5. **Floating Retainer!**
Ball retainer is designed to float on ground inner surface of outer race . . . traps lubricant and prevents churning.

Invite the SEALMASTER engineer to give your company the full story on SEALMASTER bearings. If you have a special bearing problem . . . put it up to him for recommendation.

FACTORY REPRESENTATIVES AND DEALERS IN ALL PRINCIPAL CITIES

Variable Speed Drive is for Light, Continuous Duty

Model 10 is for use with instruments, office machinery, small mixers, light conveyors, timers, recorders, and other light applications.

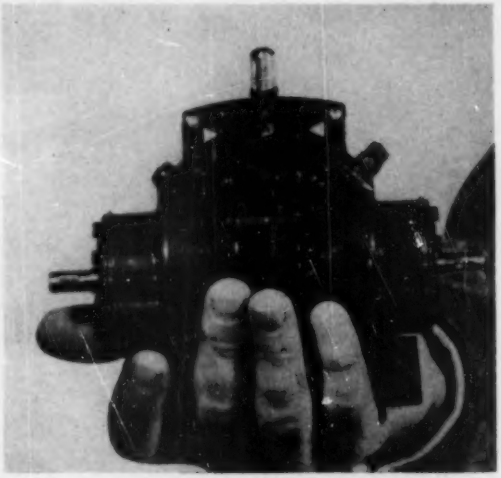
Several unique construction features have been used to make it possible to manufacture this accurate, infinitely variable speed drive at a low cost.

These features include use of two identical housing halves which eliminate the need for end covers, a one-piece roller carrier integral with the input shaft, a ring gear integral with the output shaft, and a name plate that also serves as a speed indicator dial and control locking device.

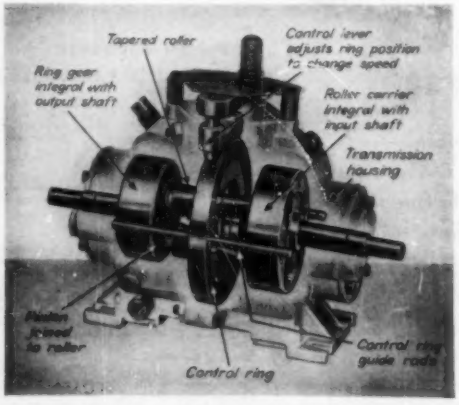
For most applications, the Model 10E with spring loading is used to give output speeds from 1,200 rpm to zero when run at an input speed of 1,800 rpm, and torque of 50 inch ounces over the entire range. The Model 10 without spring loading is used only for extremely light applications where the torque requirement is 15 ounce inches or less. Built-in reduction gearboxes with ratios from 3:1 to 1000:1 are available and make a compact package of variable speed drive and gear reducer in a single unit requiring only four mounting screws,—with delivered torque up to 800 inch ounces.

A lever type control permits the transmission to be set accurately at an infinite number of speeds. The transmission will hold speed at given settings, and may be reset with great accuracy. The lever may be connected through suitable linkage to automatic control devices of various types— mechanical, hydraulic, electric, pneumatic, etc. The unit also comes with micrometer control.

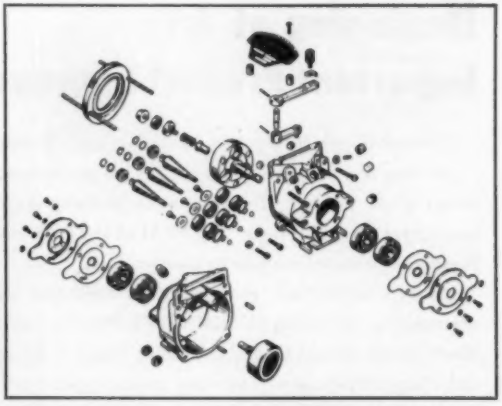
Graham Transmission Inc., 3754 North Holton St., Milwaukee 12, Wis.



ONLY 6¼ in. long and 3¼ in. in width, the model 10E gives up to 50 ounce inches of torque at output speeds varying from 1,200 rpm to zero. Model 10E uses spring tension on the tapered rollers. Model 10, using centrifugal loading only, gives up to 15 ounce inches of torque, and is for very light applications.


Tapered roller
Control lever adjusts ring position to change speed
Ring gear integral with output shaft
Roller carrier integral with input shaft
Transmission housing
Pinion keyed to roller
Control ring guide rods
Control ring

THREE TAPERED ROLLERS are supported in the roller carrier, which turns at input speed. These rollers are loaded centrifugally or by spring tension against a hardened and ground traction ring, which is moved lengthwise by the control ring to change speed. Rollers are supported at an angle equal to their taper to make outer edge parallel to the central axis. Pinions on end of tapered rollers mesh with a shaped internal gear to furnish output.

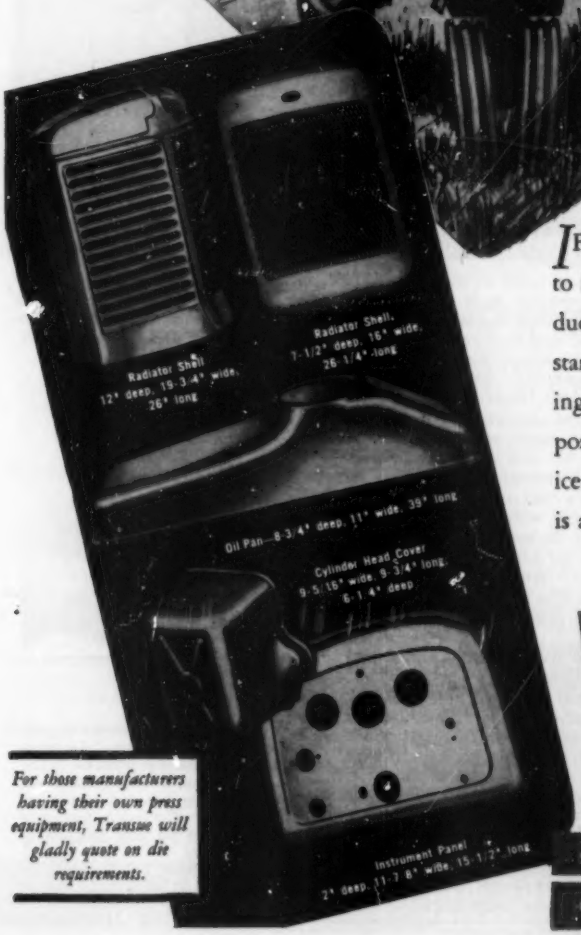


EXPLODED VIEW shows construction details and assembly. The three finely ground alloy steel traction rollers, and the input and output shafts turn in precision ball bearings. The transmission is self-lubricated and equipped with oil level and oil drain plugs. Sealed bearings permit mounting the transmission in any position. The control lever can be connected through a suitable linkage to automatic control devices. A micrometer type control, for fine adjustment, is also available on order.

CONTINUED ON PAGE 180

T and W
STAMPED TRACTOR PARTS

No. 1 of a Series


Radiator Shell
12" deep, 19-3/4" wide, 26" long
Radiator Shell
7-1/2" deep, 16" wide, 26-1/4" long
Oil Pan—8-3/4" deep, 11" wide, 39" long
Cylinder Head Cover
9-5/16" wide, 9-3/4" long, 6-1/4" deep
Instrument Panel
2" deep, 11-7/8" wide, 15-1/2" long

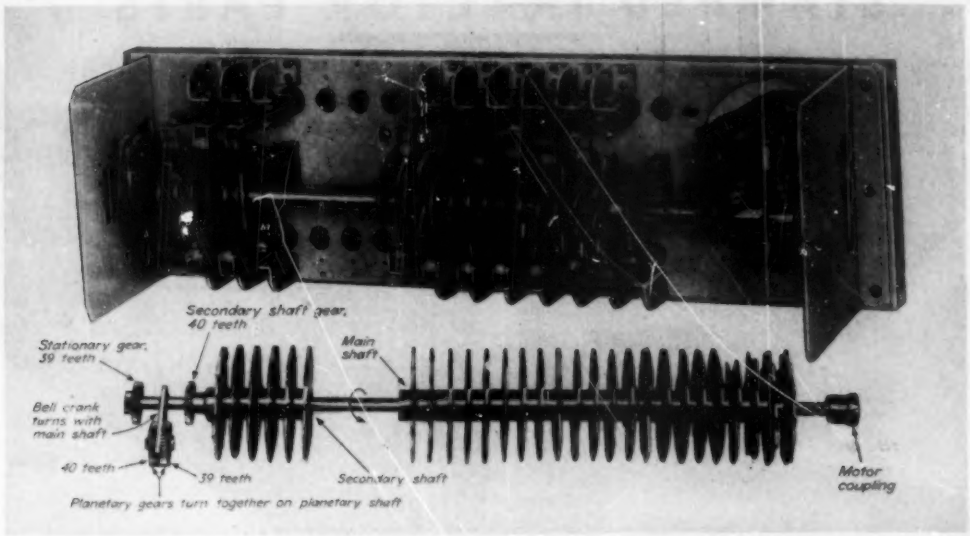
For those manufacturers having their own press equipment, Transue will gladly quote on die requirements.

IF you are interested in redesigning to improve your product and cut production costs—these deep drawn steel stampings, made by Transue for leading tractor manufacturers, may suggest possibilities. Transue engineering service is free of cost or obligation—and is available to you.

Designers and Makers of Deep Drawn Stampings

TRANSUE & WILLIAMS
ALLIANCE, OHIO

SALES OFFICES, NEW YORK, PHILADELPHIA,
CHICAGO, DETROIT, INDIANAPOLIS, CLEVELAND



MADE FOR PRECISION TIMING, this device has nylon rollers turning on hardened, polished, and chromium plated steel shafts attached to the main spring of each switch. The switch main spring is steel, and the transfer springs are beryllium copper.

Timer Gives Accurate Cyclic Interruption

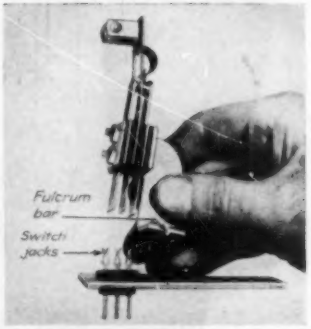
Developed originally for use in dial telephone exchanges, this motor-driven timer and circuit interrupter is adaptable to sequence timing and impulse generation for control of industrial processes, electrical displays, and automatic machinery. It is designed for continuous duty, with accuracy of timing within less than 1 percent of the cycle time on any of the switch contacts.

The main cam shaft carries up to 22 cams, each operating a snap action break-make switch. By use of a set of planetary gears, a secondary hollow cam shaft coaxial with the main shaft is driven at a speed of the order of one-twentieth of the main shaft speed. The secondary shaft carries up to six cams, which are used in telephone service for obtaining relatively long intervals for delayed alarms, conversation timing, and automatic fault lockout. For other services, this secondary shaft can be used for timing a separate process of widely different time cycle than the main shaft, or, since the ratio of its speed to that of the main shaft is fixed, it can provide pulses for marking particular numbers of cycles of the main shaft.

The cams are made of cold-rolled steel. They are copper-brazed to the hubs and case-hardened, after which the cam surfaces are polished and chromium plated. The cam shafts are tubular steel, centerless ground for accuracy of diameter, case-hardened, chromium plated, and straightened to within 0.002 inch total indicator reading. The ends of the main shaft are bored to within 0.001 inch total indicator reading with the outside diameter to receive the stub shaft at the motor end and the bell crank shaft on the other end. Holding these tolerances is necessary to keep eccentricity of the cams to a minimum for accurate timing.

Each of the switches is jacked into a three-point jack. The individual switch jacks are wired to a main jack at the rear of the base plate, and the motor leads are run to a twist-lock connector, so that the whole interrupter may be readily removed from its mounting by removing two nuts.

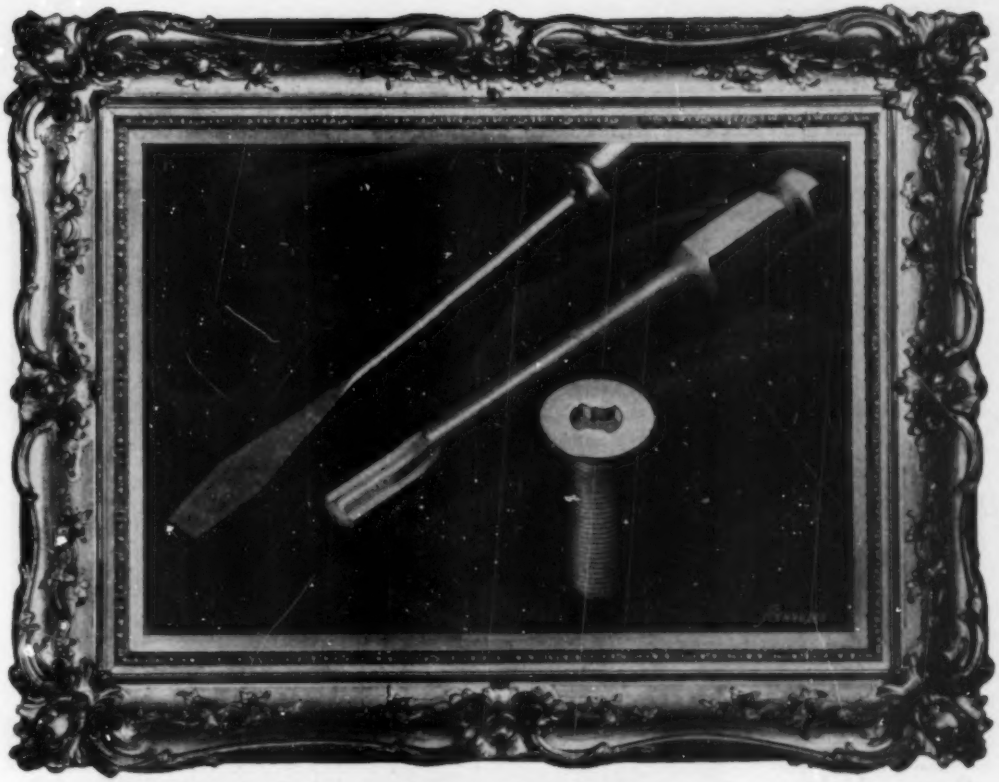
The motor is a double-reduction speed-reducer, a-c synchronous type, interchangeable with a d-c speed-reducer motor. The commonly used speeds are a six- or eight-second cycle for the main cam shaft and a two-minute cycle for the secondary shaft.



SWITCHES are normally equipped with silver alloy contacts, but any of the usual contact metals can be supplied. The switch main spring is spring steel, and the transfer spring and curl spring are beryllium copper. The jack-in feature of each switch makes for easy changing to any type of contact.

Stromberg-Carlson, 111 Carlson Road, Rochester 3, N. Y.

CONTINUED ON PAGE 182



Acclaimed a Masterpiece...

CLUTCH HEAD *Brightens the Profit Picture with 15% to 50% Assembly Increases*

Here is how CLUTCH HEAD'S modern design meets today's competitive selling problem of *"How to Produce More for Less"*... by effecting time and cost savings that quicken production steps all the way down the assembly line.

High Visibility of the roomy recess presents an easy-to-hit target. "Green" operators require no break-in. They drive with speed and confidence that checks out slow-down hesitation.

Chewed-up Heads Eliminated because dead-center entry with the Center Pivot Column prevents driver canting and makes straight driving automatic.

Safe Non-tapered Driving eliminates the danger of driver skidding from "ride-out" as set up by tapered driving . . . an important safety factor for the protection of manpower and material.

Zero in Skid Damage is reported by CLUTCH HEAD users. The all-square contact of the straight-sided driver with the straight-walled recess makes high torque driving almost effortless.

A Fatigue Factor Disposed Of. Absence of end pressure means safer, faster, easier driving. No end-of-the-shift lag means more screws driven for higher production.

Up to 214,000 Screws Driven non-stop by the Type "A" Bit . . . without interruption for tool change or reconditioning. Add to this record performance the fact that a 60-second on-the-spot operation restores this bit to original efficiency . . . *repeatedly*.

The Lock-On Overcomes Fumble Spots. A reverse turn of the bit in the recess forms a frictional hold that unites screw and bit as a unit. This permits quick, easy one-handed reaching to inner spots.

Speeds Field Service Too. With the Type "A" Hand Driver, field service men find it easy to withdraw "frozen" screws undamaged and safely held by the Lock-On on the end of the bit for re-use.

Common Screwdriver Operation. This is th *ONLY* modern screw with a recess basically designed for operation with a flat blade . . . which need only be reasonably accurate in width. Important to simplified field service.

CLUTCH HEAD SCREWS

These highlights of America's Most Modern Screw are fully detailed and illustrated in the NEW CLUTCH HEAD BROCHURE. *Send for your copy and indicate the sizes and types of screws that interest you.*

UNITED SCREW AND BOLT CORPORATION

CLEVELAND 2 · CHICAGO 8 · NEW YORK 7

New Expanded Plastic Is Lightweight Insulator

Called Plasti-Cell, this new material is produced in flexible molded shapes. Vinyl paste dispersions (Marvinol), are processed to form an expanded unicelluar polyvinyl chloride composition which ranges from 2 to 12 lb per cubic foot. This lightweight, plus extremely low water absorption, creates a great buoyancy. The compression molding range of Plasti-Cell runs from 1½ psi to 150 psi, depending on the type of product required. Insulation value is illustrated by a K factor of 0.20 or less, depending or density. Excellent electrical properties are claimed. The material is non-toxic, odorless and tasteless. The company anticipates wide usage of the material in flotation and in special insulation. However, it is emphasized that this expanded plastic will not replace cellular rubber. Plasti-Cell is inherently thermoplastic, and this disqualifies it for functions now best performed by cellular rubber.

A VARIETY of typical shapes are shown. Plasti-Cell has good electrical properties, is a good heat insulator, and is lightweight and is extremely buoyant.

The Sponge Rubber Products Co., Shelton, Conn.

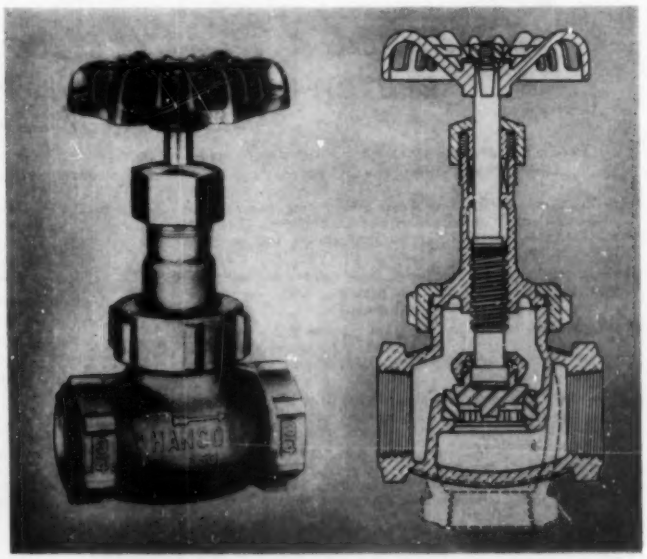
Bronze Valves Have Extra-Hard Seats, Disks

Seats and disks are hardened to 500 Brinell to protect valve from wire drawing, steam cutting, and erosion.

Designed for 150 psi service with saturated steam, these valves will take up to 300 psi non-shock use with cold water, oil, or gas. They are made in both globe and angle types with screwed ends, and in sizes ranging from ¼ to 2 in.

The renewable plug seats and disks of stainless steel are heat treated to 500 Brinell and honed to minimize wire drawing, steam cutting, erosion and corrosion. They are not affected by boiler scale, pipe turnings, or any other foreign substances that normally enter the line. The company claims a greatly increased diaphragm strength for this new valve.

Handcock Valves, Manning, Maxwell & Moore, Inc., Watertown 72, Mass.



MADE IN BOTH globe and angle types, screwed ends, these valves feature a high strength aluminum-silicon bronze stem, extra-hard renewable plug seats and disks of stainless steel, and a new diaphragm construction.

CONTINUED ON PAGE 184

Timesaver for machine designers ...the complete CRANE line

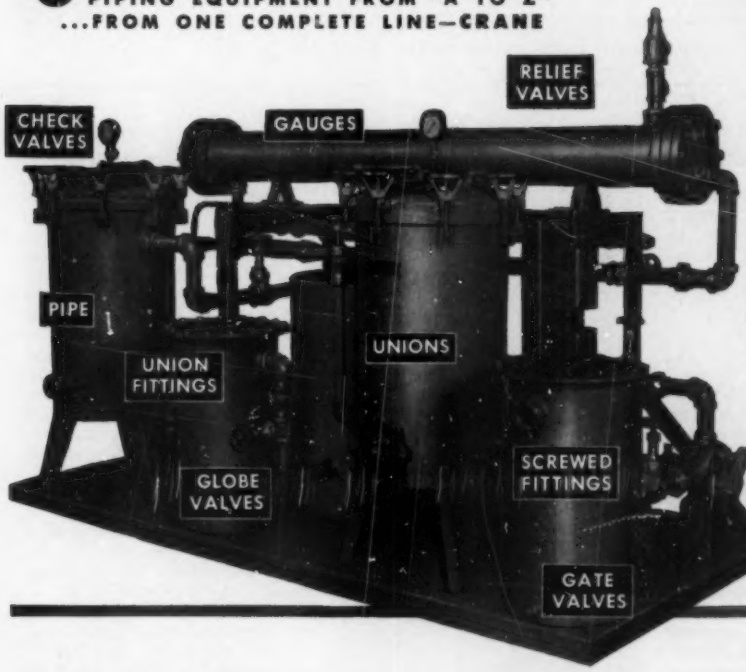
Suppose you are designing this *Heat Exchanger.* What is the best . . . and quickest . . . way to specify all the piping equipment your design calls for? Your answer: Turn to your Crane Catalog—listing the world's most complete line of valves, fittings, pipe and accessories.

The ability to specify everything from one catalog . . . get everything from one supplier . . . simplifies all piping procedures, from original product design to final product assembly. In addition, the name "Crane" on piping equipment gives your design added value. For your customers know that in materials and construction Crane products are unsurpassed for quality.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas

RUGGED AND DURABLE, *Crane No. 428 Brass Gate Valves have solid wedge disc accurately guided to prevent contact between seating surfaces until valve is almost closed. Rising stem; screwed ends. Working pressures: 125 pounds steam, 200 pounds water, oil, or gas. Sizes: ¼ to 3 in. See your new No. 49 Crane Catalog, p. 16.*

PIPING EQUIPMENT FROM "A TO Z" ...FROM ONE COMPLETE LINE—CRANE



Heat Exchanger by Bell & Gossett Co., Morton Grove, Ill.

EVERYTHING FOR EVERY PIPING SYSTEM **CRANE**

VALVES • FITTINGS • PIPE • PLUMBING AND HEATING

Electronic Counter Rated at 60,000 Counts per Minute

The Model 133 Three-Decade Predetermined Electronic Counter will predetermine any count from 1 to 999 continuously and provide a high-speed relay action each time the selected predetermined count is reached. Other models have capacities of 2, 3, 4, 5 and 6 digits, are also available. Unlike the older models, which required a complementary setting of the number, the predetermined count is selected directly by means of dial switches conveniently located on the front panel. The new counters will count at rates up to 60,000 per minute with absolute accuracy and will reset instantaneously without missing a count.

Since the counters are completely electronic and contain no moving parts to wear, maintenance is practically eliminated. Each tube in the counting circuit has associated with it a small neon glow lamp which, in addition to indicating the progression of count, makes it possible to quickly locate and replace a defective tube.

In addition to the usual counting operations, such as buttons, tinplate, screws, nails, paper, molded and stamped parts, boxes and cans, the Predetermined Electronic Counter is also ideal for precise frequency with measurements, predetermining time intervals, generating square waves and frequency dividing.

The output consists of a high-speed mercury type relay which operates in 2 milliseconds. Several different types

of relay actions are available. One type, which is ideal for the control of push-pull solenoid deflector mechanisms, consists of a single-pole double-throw action that reverses each time the selected predetermined count is reached. Another type provides adjustable momentary contact closure at the predetermined count. Time of closure can be set.

The Potter Instrument Co., Inc., 136-56 Roosevelt Ave., Flushing, N. Y.

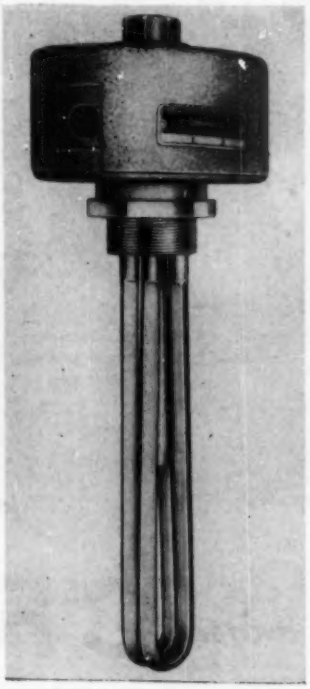
Immersion Heater Is Thermostatically Controlled

This new screw-plug immersion heater is for use with such chemical and oil solutions as tar, parrafin, asphalt, solvents, and other viscous and corrosive liquids.

One-half inch diameter hairpin tubular elements are welded or silver-soldered into a standard screw-plug for easy mounting in pipes and through the walls of tanks. Standard heaters are fabricated of either copper heating elements with a brass screw-plug, or steel elements with a steel screw-plug, depending upon the corrosive properties of the solution to be heated.

The built-in thermostat has a temperature range of 60 to 250 deg F for heating water type solutions, or 200 to 550 F for oil and other viscous compounds. Temperature is controlled by an adjustment knob on the outside of the sheet-steel thermostat housing. The sensitive thermostat bulb is encased in a protective well mounted on the screw-plug and extending between the heating elements. The well is constructed of either copper or steel.

Edwin L. Wiegand Co., 7535 Thomas Blvd., Pittsburgh 8, Pa.



Kit Contains Parts For Vibrator Installation

These "LVF" vibrator kits, which consist of a pneumatic vibrator, a control valve, and an air line lubricator, contain all parts necessary for an efficient vibrator installation and have been developed to meet the requirements of a wide range of materials handling applications.

"LVF" kits also contain nipples and connectors necessary to permit rapid, easy attachment of the vibrator assembly to hoppers and storage bins handling bulk sand, coal, lime, ore, cinders, slag, steel chips, cement, soda ash, etc.

Any one of six standard Cleveland vibrators can be furnished in an "LVF" kit. Piston diameters of these six sizes range from 1¼ to 4 in., overall widths from 3 to 7½ in., and over-all lengths from 6 to 15 in. Extra large and heavy-duty models can be supplied upon request.

Speeds of operation for the vibrators furnished in "LVF" kits, computed on line pressure of 80 psi, range from 2,100 vibrations per min on the smallest model to 750 vibrations per min on the largest unit.

The Cleveland Vibrator Co., 2774 Clinton Ave., Cleveland 13, Ohio

END

Where does Felt serve in your factory?

There isn't a plant in this country that does not make use of felt in some way. It is one of the hidden but important engineering materials that help industry make better products and improve plant operations. In an automobile, for example, there are some 90 different applications of felt, and in an automobile plant at least another 90. Many of these are not apparent by casual inspection but long life, smooth performance, freedom from vibration and positive lubrication are frequently the result of well engineered, reliable felt parts. Check your plant and your products — are you making full use of the many advantages offered by felt?

1 MOTORS 2 VIBRATION MOUNTINGS 3 SHOCK DAMPENERS 4 GENERATORS 5 OIL BURNERS 6 HANGER OILERS 7 BALL BEARINGS 8 ROLLER BEARINGS 9 WORKERS FLOOR PADS 10 BUFFING WHEELS 11 CASTERS 12 TRUCKS 13 PASSENGER CARS 14 TRACTORS 15 FAUCETS 16 OIL RETAINERS 17 DUST SHIELDS 18 WORK SHOES 19 OIL WIPERS 20 FILTERS 21 VENTILATORS 22 WICKS 23 THERMAL INSULATION 24 GRINDING 25 GOGGLE SHIELDS 26 FOUNDRY GLOVES 27 RESPIRATORS 28 SANDER BELTS 29 HOSPITAL SUPPLIES 30 COMMISSARY EQUIPMENT 31 WEATHERSTRIP 32 BULLETIN BOARDS 33 SWITCH BOARDS 34 RELAY BOARDS 35 TELEPHONES 36 TELETYPE 37 TELEGRAPH 38 P.A. SYSTEM 39 RADIOS 40 BUSINESS MACHINES 41 TYPEWRITERS 42 DUPLICATING MACHINES 43 POLISHING 44 CHAIR PADS 45 LEDGER CORNERS 46 DOOR BUMPERS 47 GLASS DESK TOP STRIPS 48 BLOTTER PADS 49 TABLE TOPS 50 AIR CONDITIONING 51 COLD LINE INSULATION 52 SOUND ABSORPTION 53 ASH TRAY BASES 54 CIGARLIGHTERS 55 LAUNDRY EQUIPMENT 56 INSULATION 57 SEWING MACHINES

The uses shown here are mainly generic, because there are hundreds of places in the modern factory where felt is used. American Felt is made in many standardized types, and is an engineered fabric that can be specified as accurately as any other material.

American Felt Company

TRADE MARK

GENERAL OFFICES: 36 Glenville Road, Glenville, Conn. — ENGINEERING AND RESEARCH LABORATORIES: Glenville, Conn. — PLANTS: Glenville, Conn.; Franklin, Mass.; Newburgh, N. Y.; Detroit, Mich.; Westerly, R. I. — SALES OFFICES: New York, Boston, Chicago, Detroit, Cleveland, Rochester, Philadelphia, St. Louis, Atlanta, Dallas, San Francisco, Los Angeles, Portland, Seattle, Montreal.

© 1949, American Felt Co.

Grooming the Horses TO RIDE IN THE MONEY

You needn't be concerned with horses, real or mechanical, to profit from the experience of a roving amusement ride operator in Michigan.

He liked to give the youngsters a real whirl for their money. But he couldn't make money when the spinning horse carts broke down or when the kids were so jolted by abrupt starts that they were afraid to ride. Operating difficulties were spoiling the fun — and the profits.

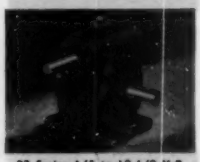
At wit's end, the troubled operator called in Winsmith. It turned out to be true that a stock Winsmith reducer fit the job as a nut fits a bolt. But what really brightened the profit picture were the transmission improvements recommended by the Winsmith factory trained engineer who called. Effected at a negligible cost, they accomplished smooth, low-torque starting, permitted discarding of unpopular safety belts and eliminated shaft breakages. No more profit losses — the mechanical steeds now ride in the money.

Your applications of power transmission may be remote from the amusement field. They may call for large, heavy duty speed reducers to operate sewage sludge agitators, or for fist-size units to rotate a glittering array of appliances on a display table.

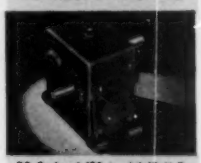
Whatever the use, it's worth remembering that with Winsmith you get *widest* selection of stock reducers anywhere — and at the *lowest* cost. But what the ride operator remembers most about Winsmith is what will impress *you* the most from your very first contact . . . unique individualized service by factory trained transmission engineers.

DSRA Series 1/20 to 1/8 H.P.

BV Series 1/3 to 12-1/2 H.P.


BT Series 1/3 to 12-1/2 H.P.

B Series 1/3 to 12-1/2 H.P.


DB Series 1/30 to 4-1/2 H.P.

Ptd. Differential 1/10 to 81-1/2 H.P.

BDV Series 1/100 to 4-1/2 H.P.

BX Series 7/8 to 8-1/2 H.P.

CATALOG HANDBOOK No. 148
If you have it, get your name on the mailing list for new 1950 edition by writing today.

WHS WINSMITH SPEED REDUCERS

WINFIELD H. SMITH CORPORATION

111 EATON ST., SPRINGVILLE, ERIE COUNTY, NEW YORK

OUR READERS SAY

Myth or Truth?

To the Editor:

The view in your article entitled "Beryllium's Toxicity is Largely Myth", page 155, September 1949—PRODUCT ENGINEERING, is not shared by some authorities in the field of Industrial Hygiene.

Reference is made to the three following excerpts:

(1) Industrial Hygiene and Toxicology—Frank A. Patty, Editor. Copyrighted 1949 by Interscience Pub. Inc. Volume 2, pages 683 and 684.

(2) American Industrial Hygiene Association Quarterly, June 1949, page 45. See article "The Use of Beryllium In New York State."

(3) Industrial Medicine and Surgery, Oct. 1949, pages 428 through 431.

The points brought out in your article were noteworthy, but at the same time we should recognize the hidden dangerous qualities of beryllium, and learn to control them.

—WILLIAM O. BIANCONI
Florence, Ala.

Ed—We hope you are wrong, Mr. Bianconi. We made a fairly extensive survey of the existing literature and tried to write an honest report of the beryllium situation as we saw it.

However, we did say in our article that intelligent industrial health measures are always important in any operation. We also gave some of the common precautions to be taken in dealing with beryllium and its alloys.

The Compressor's the Thing

To the Editor:

Your article about the new supersonic wind tunnel at Langley Field, Virginia as it appeared in the November Technical News section was lacking in just one respect. It did not mention that the specially designed axial-flow air compressor was designed and constructed by our engineers.

—G. C. QUINN
Allis-Chalmers Mfg. Co.

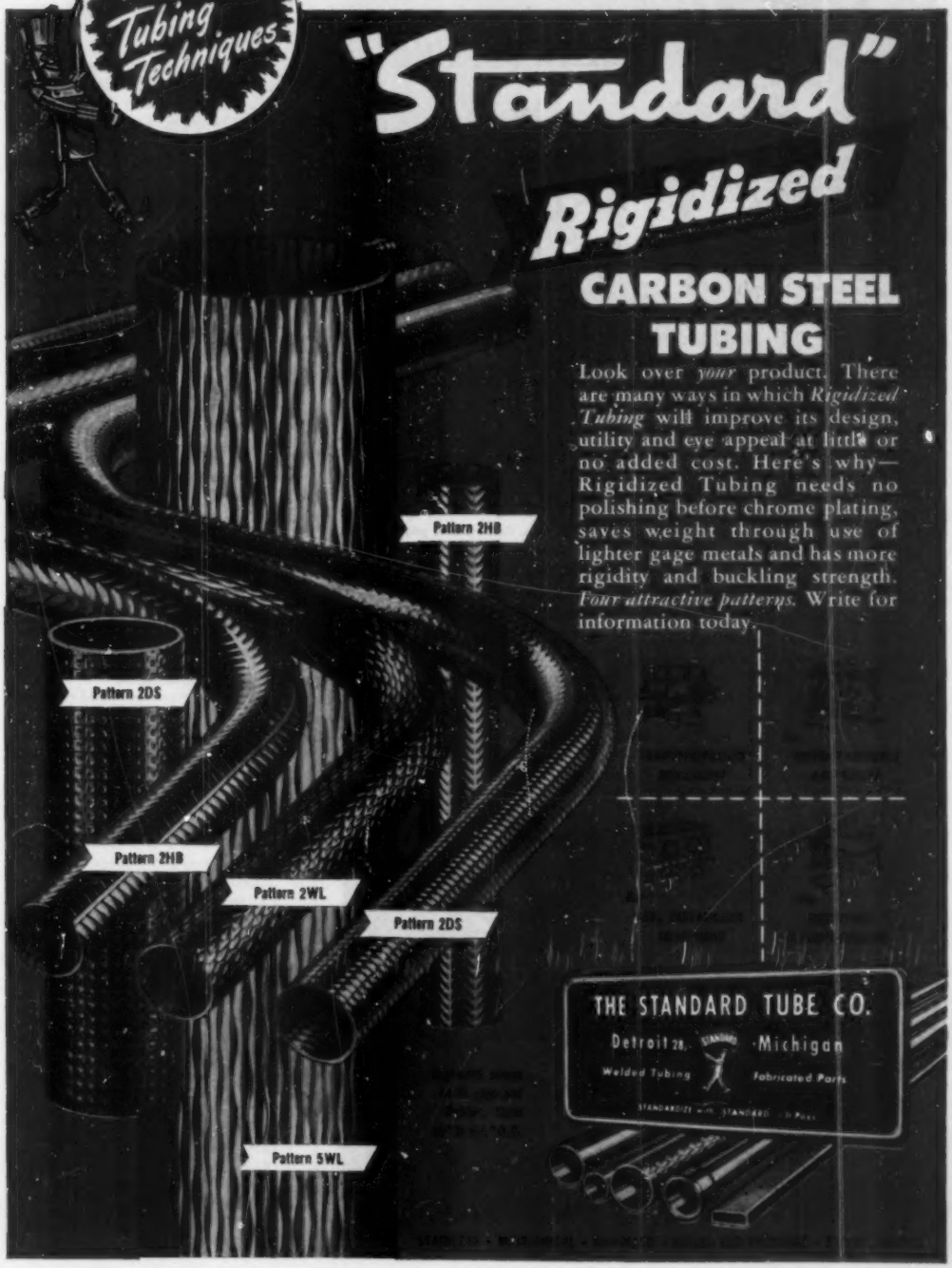
Ed—The original release for this material came directly from the NACA at Langley Field, and did not mention Allis-Chalmers' part in this wind tunnel project. We are happy to complete

"Standard" Tubing Techniques

Now—*1001* New Opportunities with

"Standard" Rigidized CARBON STEEL TUBING

Look over *your* product. There are many ways in which *Rigidized Tubing* will improve its design, utility and eye appeal at little or no added cost. Here's why—Rigidized Tubing needs no polishing before chrome plating, saves weight through use of lighter gage metals and has more rigidity and buckling strength. *Four attractive patterns.* Write for information today.



ORANGE Roller Bushings combine *all* the essentials for successful needle bearing application. They have become the No. 1 choice of design engineers wherever needle bearings are required in their equipment. Here's why:

Orange Roller Bushings are made to extreme standards of precision. All raceways are through-ground to a friction-free finish. Roller clearances are held to a minimum through rigid standardization of size, resulting in closer internal running clearances. This minimizes possibility of misaligned rollers while running.

The full benefit of these features shows up in the long, trouble-free protection given your equipment by Orange Roller Bushings. Next time your designs call for needle bearings, consult with our local representative on the advantages of using Orange Roller Bushings. Write for detailed Engineering Data Book showing dimensions, capacities, installation data, etc.

"General" ½ yd. Crane and Shovel

has been using Orange Roller Bushings in steering controls and chain idler sprockets for over three years with complete satisfaction. Reason? "Compactness and closer alignment of rollers" writes General Excavator Company, pioneer in small excavating equipment.

ORANGE ROLLER BEARING CO., INC.
581 Main Street, Orange, N.

our report with this acknowledgment of the part played by Allis-Chalmers Mfg. Company.

Belleville Spring Design

To the Editor:

My special interest in the Reference Book Sheets on Belleville Springs by L. W. Jones, PRODUCT ENGINEERING, January 1949, p. 161, has prompted me to investigate the accuracy of Almen and Lazlo's fundamental formulas.

I submit, herewith in the accompanying table, test data on a large Belleville spring. The test was performed with the highest degree of accuracy, therefore, its results should be a reasonable basis for comparing practical and theoretical data.

The spring tested was made from silicon-manganese steel heat-treated and quenched. The modulus of elasticity E of the material was 29,400,000 psi. The principal dimensions of the spring were

D = outside diameter = 6.73 in.
d = inside diameter = 2.750 in.
h = free height = 0.157 in.
t = thickness = 0.591 in.

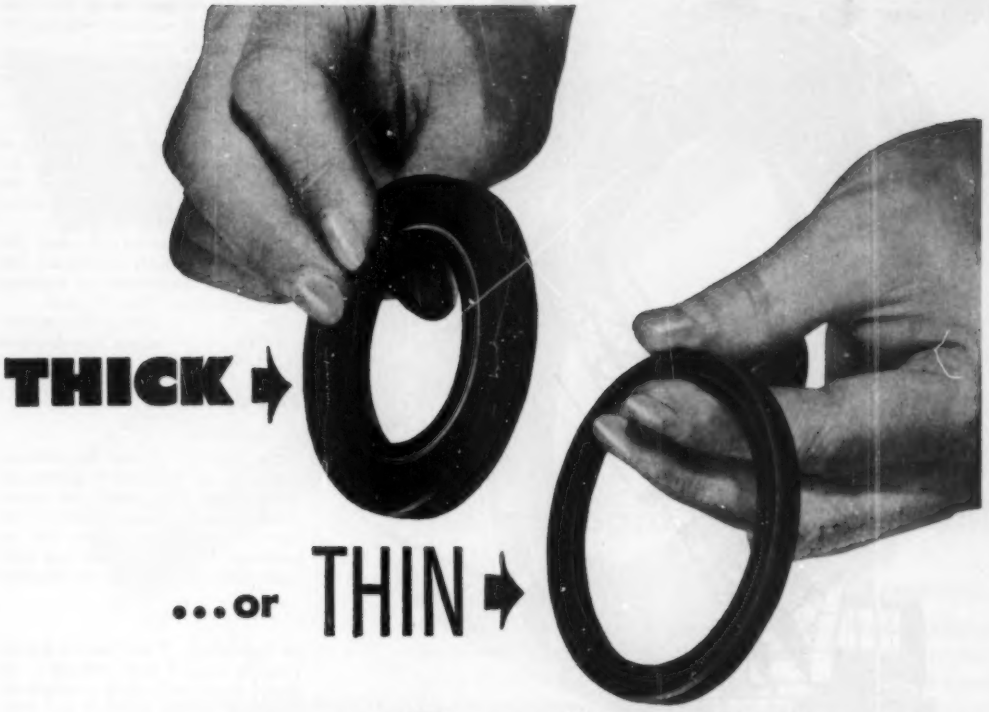
In the accompanying table

P = applied axial load checked by test, lb
f = axial deflection of disk under load P, determined by test measurements, in
P_c = axial load to produce deflection f, as calculated from Almen and Lazlo's formulas, lb
S = maximum stress at outer edge of disk, as calculated from Almen and Lazlo's formulas, psi
P_c/P = ratio of calculated load to applied load

It can be seen from the Table that the deviation between P and P_c is considerable. More disturbing conclu-

Test Number	Test	
	P, lb	f, in
1	22,040	0.0344
2	44,080	0.065
3	55,100	0.0815
4	66,120	0.0975
5	70,550	0.105
6	75,000	0.11
7	79,300	0.1166

Test Number	Calculations		P_c/P
	P_c, lb	S, psi	
1	28,800	136,000	1.30
2	53,500	278,200	1.21
3	66,600	344,300	1.21
4	79,000	407,500	1.19
5	85,000	437,500	1.20
6	88,800	456,000	1.185
7	94,600	480,000	1.195



...an oil seal design for any cavity

CLIPPER SEALS offer unusual design possibilities . . . and unusual design economies, too.

For example, this new Johns-Manville oil seal is available in flange sections of varying width to fit practically any cavity. In fact, because of the adaptability of its unique one-piece design, there is no cavity mechanically practicable which is too shallow—or too deep—for a Clipper Seal.

Furthermore, because the Clipper Seal has no metal case and is of flexible molded construction, this oil seal permits liberal machining tolerances in the design of the cavity. Its tough, dense outer heel is resilient enough to conform to even a slightly out-of-round cavity. Yet this does not interfere with the seating of the pliable inner lip which always maintains a light, but positive sealing pressure on the shaft for minimum wear.

Clipper Seals are entirely non-metallic, which eliminates the possibility of electrolysis; are available in split and endless types, for sealing against oil, grease, water, air, grit and coolants, in sizes from ¼" I. D. to 66" O. D. If you would like to consult us about a design problem, write Johns-Manville, Box 290, New York 16, N. Y.

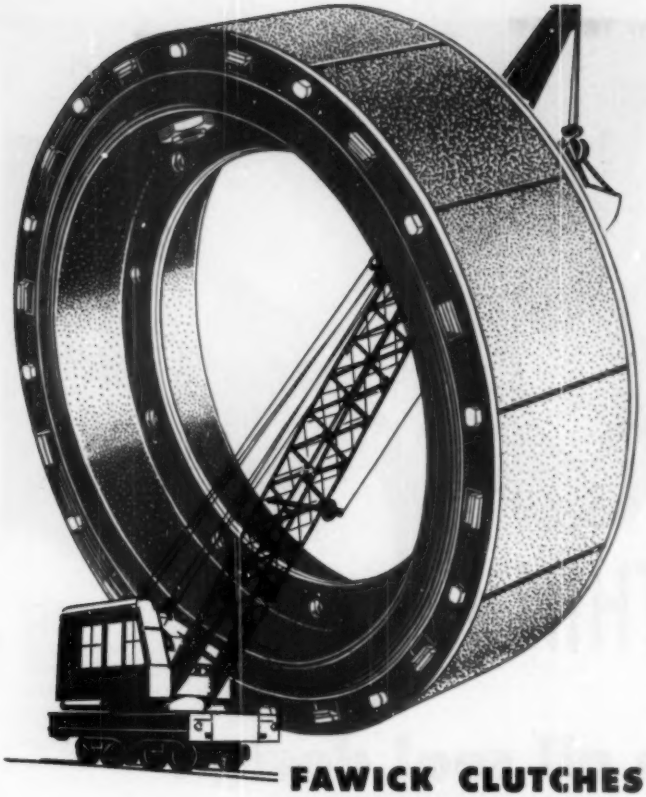
JM

Recommended Clipper Seal Flange Sections

Shaft Diameter Inches	Increments	Light Flange Width	Light Heel Depth	Medium Flange Width	Medium Heel Depth	Heavy Flange Width	Heavy Heel Depth
½ thru 1½	1/16"	¼"	5/16"	5/16"	5/16"	3/8"	7/16"
1 9/16 " 2	1/16"	5/16"	5/16"	3/8"	7/16"	½"	7/16"
2⅛ " 2⅞	⅛"	5/16"	5/16"	3/8"	7/16"	½"	7/16"
3 " 8⅞	⅛"	3/8"	7/16"	½"	7/16"	5/8"	9/16"
6 " 9⅞	⅛"	½"	7/16"	5/8"	5/8"	5/8"	5/8"
10 " 19¾	¼"	3/8"	½"	3/8"	9/16"	1"	¾"
20 " 29¾	¼"	¾"	½"	1"	¾"	1¼"	¾"
30 " 36	¼"	1"	¾"	1¼"	¾"		

Recommended dimensions for shaft diameters from ½" to ⅝" and over 36" on request.

Johns-Manville PACKINGS & GASKETS



FAWICK CLUTCHES PROVIDE

THREE-WAY EFFICIENCY

ON OHIO LOCOMOTIVE CRANES

The eight E-type Fawick Airflex Clutches on this locomotive-type crane supply the entire functional clutch system.

These Fawick units provide instant response through finger tip control necessary for efficient over-all crane operation. The clutches function for travel, swing, boom hoist, hoisting, and boom operations.

Altogether, the installation of Fawick units provides the crane with (1) long-wearing clutches, (2) faster operating cycles, (3) low maintenance and repair time.

For specific information on all advantages of Fawick Industrial Clutch and Brake Units, write to the Main Office, Cleveland, Ohio, for Bulletin 300.

All desirable clutch characteristics are built into Fawick Airflex units

FAWICK Airflex CO.

sions must be made when the calculated stress S is compared with the tensile strength of material.

Taking the ultimate tensile strength of silicon-manganese steel at 215,000 psi, the calculated stress S is much greater in all tests except Test No. 1. If S were the true stress, cracking of the spring would be unavoidable. Actually in all tests except No. 7, the test stress did not exceed the elastic limit of the material.

In view of this data, it seems that in applying Almen's and Lazlo's formulas some corrections are necessary to establish true values of stress.

—Victor Tatarinov,
Consulting Engineer

Erratum

To the Editor:

On page 161 of your December issue, a set of temperature curves and an equation for springs are given. These have a common variable S, and may be combined as shown, the A-t curves being replotted with log ordinates, since the scales for the equation

$$P = \frac{\pi d^3 S}{8 D}$$

are logarithmic. When these scales are properly located and graduated, the dotted secants will show a sample relationship entirely graphical and without calculation. It would save space and not be confusing if the S-t curves were folded over on the S scale as an axis.

In the same issue page 165, there is a nomogram for piston pumps, in which there are no less than 11 graduated scales, with 5 secants crisscrossing every way. Undoubtedly the maker knows what secant cuts what scale—"He knows about it all—He knows—He knows", but do we? Not without some accompanying descriptive matter, which we don't find. The editor should try it first, and failing ask for elucidation (or put it in the puzzle department).

The writers' method for this is to draw very small circles at all the significant scale intersections, and interrupt the secants where the crossings are to be ignored. Or put a little hump in one to show that it doesn't cut the scale.

This with the numbering of the secant renders further explanation unnecessary. When again it is well to remember that it is no act of supererogation to set the equation on the page with the nomogram.

—Carl P. Nachod
V. P. Nachod & U. S. Signal Co. Inc.

Ed—Of course Mr. Nachod is right as usual. We had a rather lengthy explanation made up for inclusion on the

of the Brass Rod Industry

the standard of comparison!

There is a difference in brass rod—A BIG DIFFERENCE.

Some mill men say there is no difference in FREE CUTTING Brass Rod made by different Brass Mills. They reason that since all mills use the same class of raw materials, the same type of equipment, and in addition, since all are controlled by well-equipped laboratories and technical departments, the product must be the same.

However, the men who actually operate the machines at rod consuming shops, who buy rod from more than one mill and who are really in a position to make true comparisons say, "THERE IS A DECIDED DIFFERENCE." Many of these consumers operate their machines on the same parts for long periods, and gradually the product of one particular mill BECOMES THE STANDARD OF COMPARISON for BRASS ROD of all mills.

Mueller Brass Co. Red Tip FREE CUTTING Brass Rod is the yardstick with many of the largest rod consumers, and since it enjoys this rating, it is usually selected for the tough jobs.

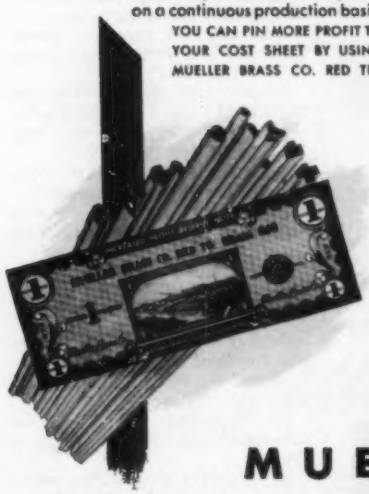
We have the "know-how" to produce the best in Brass Rod for any purpose. If you want it for long runs where special properties are required, our Technical and Metallurgical engineers are at your disposal. Worthwhile savings can be made.

Millions of pounds of brass rod are manufactured in our mill each month. Shipment can be made at once from our large factory stocks.

YOU CAN PIN MORE PROFIT TO YOUR COST SHEETS!

Mueller Brass Co. Red Tip Brass Rod is a universal, many-purpose, extra-fast cutting Rod. Its constant uniformity saves tools, grinding and setup time. It actually can be machined at greater speeds than that of which any machine is capable on a continuous production basis.

YOU CAN PIN MORE PROFIT TO YOUR COST SHEET BY USING MUELLER BRASS CO. RED TIP.

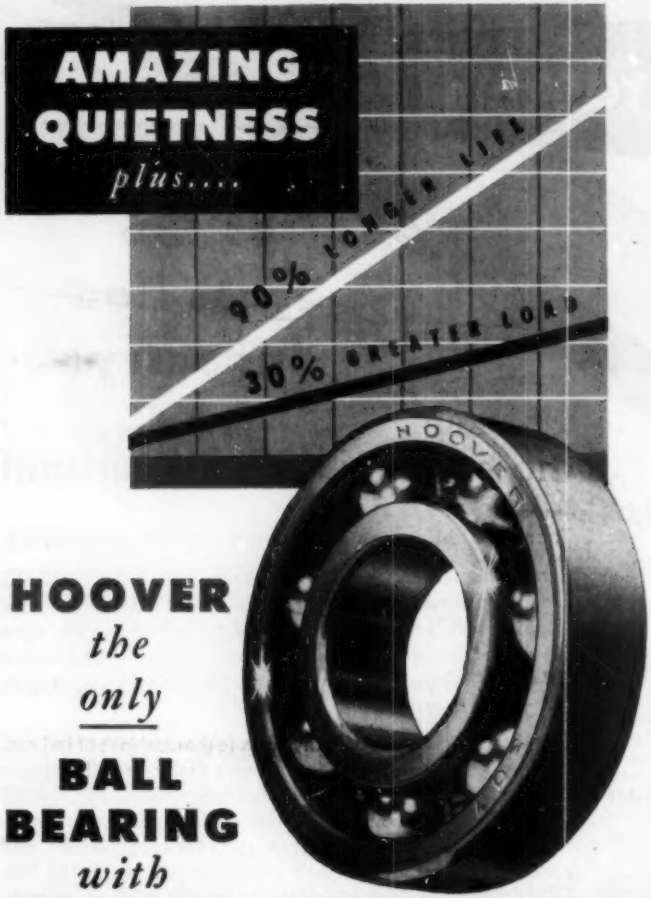


MUELLER BRASS CO.

PORT HURON • MICHIGAN

STREAMLINE PRODUCTS

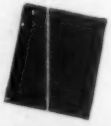
For Unexcelled Performance



HOOVER *the* *only* **BALL BEARING** *with* **HONED RACEWAYS**

Here are three pertinent reasons why you should consider Hoover Ball Bearings — with honed raceways. First, these bearings achieve unbelievable quietness. Second, they increase bearing life 90 per cent. Third they have a 30 per cent greater load capacity. When you specify Hoover Ball Bearings you secure these PLUS features without extra cost.

The Hoover Engineering Manual gives all the facts. Write for your copy.



THE ARISTOCRAT OF BEARINGS

HOOVER BALL and BEARING CO.
Ann Arbor, Michigan

same page with the nomogram. In the rush of putting the magazine together, this whole block of type was inadvertently left out. Although it is rather late in the day we would like to give a short summary of the material that should have been included in our original reference book sheet: given the stroke in inches and the piston diameter or area the displacement can be calculated in cubic inches. From the displacement and the time per stroke the quantity of flow can be calculated. From the quantity of flow and pressure the output power can be obtained. Power input can be gotten from output power and efficiency. Piston force can be read from the pressure and either the area or diameter.

We realize that the lack of this information makes our nomogram hard to understand. We hope that interested readers were able to make some use of it in spite of our error.

Powdered Metal

To the Editor:

The writer is a subscriber and reader of your journal. I am inquiring about two things.

1. The dates of issue of your journal containing articles relating to powdered metal processes.

2. Sources of supply of powdered metal.

—M. BORDEN
Simplex Valve & Meter Co.

Ed—Going back five years in our files we have published the following articles dealing with powder metallurgy:

August 1944, page 561, "Design of Powdered Metal Parts."

December 1945, page 877, "Powder Metal Machine Parts Design Characteristics and Data".

October 1946, page 98, "Powdered Metal Cold Formed into Bearings".

November 1946, page 93, "Powdered Metals Hot Pressed".

November 1947, page 116, "German Powder Metallurgy Reports".

April 1948, page 152, "Powder Metallurgy Applications and Techniques."

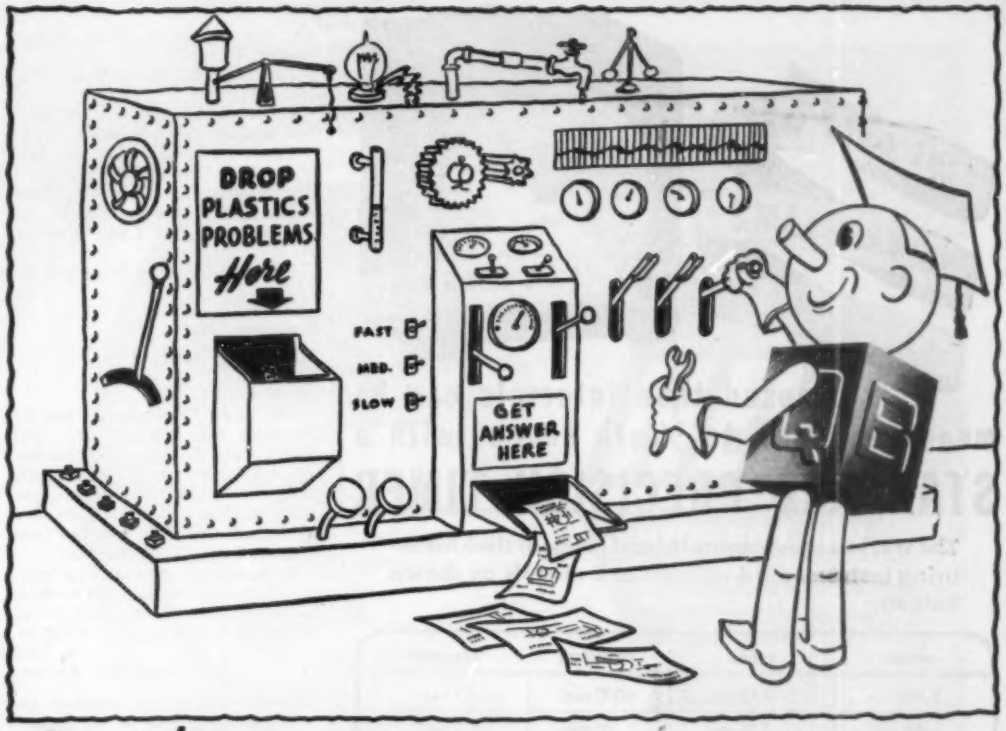
Feburary 1948, page 134, "Cost-Reducing Powder Metallurgy Techniques".

October 1948, page 107, "Nonferrous Powdered Metal Parts".

September 1948, page 102, "Nonferrous Metal Powders".

July 1949, page 123, "Ccope and Limitations of the Powder Metallurgy Process"

As to sources of powdered metals, there are literally hundreds of suppliers. Many of them supply special powdered products. These few will



It isn't as easy as this ... BUT "CUBEE"

GETS THE ANSWER TO YOUR PLASTICS PROBLEMS!

Nope it isn't that easy—it takes lots of planning and designing and figuring before most problems are solved. But we've enjoyed great success at satisfying our clients just the same.

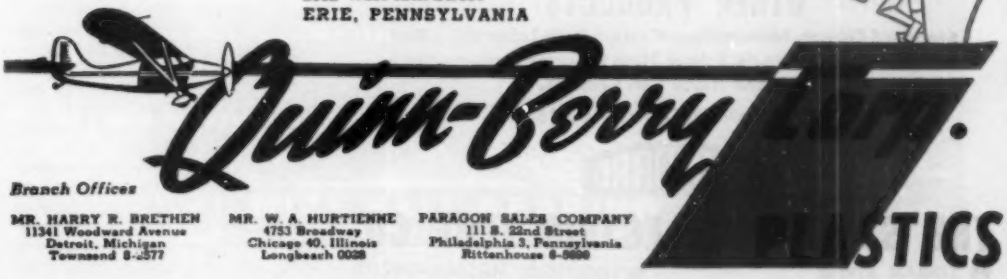
We know that, in order to help you, with your problems, we must have knowledge of materials, design, die-making, production and all the rest. We have those facilities—all under one roof—you see we're specialists in molding plastics parts—from design to finished product.

Call "Cubee" the next time you have a problem in design. We think we can help you.

Q-B Says:

"When you're planning in Plastics
And you want the very best
Give your problems to "Cubee"
And we'll do the rest".

QUINN-BERRY CORP.
2662 West 12th Street
ERIE, PENNSYLVANIA



Branch Offices

MR. HARRY R. BRETHEN
11341 Woodward Avenue
Detroit, Michigan
Townsend 8-2577

MR. W. A. HURTIENNE
4753 Broadway
Chicago 40, Illinois
Longbeach 0028

PARAGON SALES COMPANY
111 S. 22nd Street
Philadelphia 3, Pennsylvania
Rittenhouse 6-5690

Elapsed time intervals can be measured down to 1/1000th second with a

STANDARD PRECISION TIMER

The world's most accurate (and rugged) time measuring instrument. Available in 8 models as shown below:

MODEL	READS	TOTALIZES	ACCURACY
S-100	1/5 sec.	6000 sec.	± .1 sec.
S-60	1/5 sec.	60 min.	± .1 sec.
SM-60	1/100 min.	60 min.	± .002 min.
S-10	1/10 sec.	1000 sec.	± .02 sec.
S-6	1/1000 min.	10 min.	± .0002 min.
S-1	1/100 sec.	60 sec.	± .01 sec.
MST	1/1000 sec.	.360 sec.	± .001 sec.
MST-500	1/1000 sec.	30 sec.	± .002 sec.

Manually and Electrically Operated Portable Cases or Panel Mounting optional changes to conform to customers' requirements.

Special Timing Problem. **Our engineers are ready to consult with you, and design timers to meet special timing problems.**

OTHER PRODUCTS

Standard Chrono-Tachometers, Custom-built Laboratory Test and Distribution Panels, School Time Program Systems, Hospital Doctor Paging and Nurse Call Systems.

WRITE FOR BULLETIN NO. 153

STANDARD

THE STANDARD ELECTRIC TIME CO.

95 LOGAN STREET **SPRINGFIELD, MASSACHUSETTS**

give you an idea of where to start looking:

Fansteel Metallurgical Corp., Chicago, Ill.

Belmont Smelting & Refining Wks., 320 Belmont Ave., Brooklyn, N. Y.

Ekstrand & Thaland, Inc., 443 Lexington Ave., New York 17, N. Y.

New Jersey Zinc Sales Co., Front & Fletcher Sts., New York, N. Y.

American Sinteel Corp., Yonkers, N. Y.

Plastic Metals Div., Johntown, Pa.

Stainless Steel Hardening Method

To the Editor:

We would like to receive any information that you may have with regard to new developments in hardening of stainless steel. We are presently using, for our dental instruments, type 440B stainless steel. This gives us a hardness of C52 when quenched from a salt bath at 1,900 Fahrenheit.

If you know of any material or process which could increase this hardness so that we can maintain a cutting edge for a longer period, please advise us.

—N. LIEB
Star Dental Mfg. Co., Inc.

Ed—We published an article on the Malcomizing process in our January 1949 issue. This process should give you a much harder stainless steel than the standard hardening process you are now using. Although the article did not cover 440B stainless steel, it does cover 420 stainless steel which has similar characteristics. For more complete information we suggest that you contact the author of this article. He is: Vincent T. Malcolm, Director of Research, Chapman Valve Mfg. Company, 203 Hampshire Street, Indian Orchard, Mass.

Those "Leaks" Again

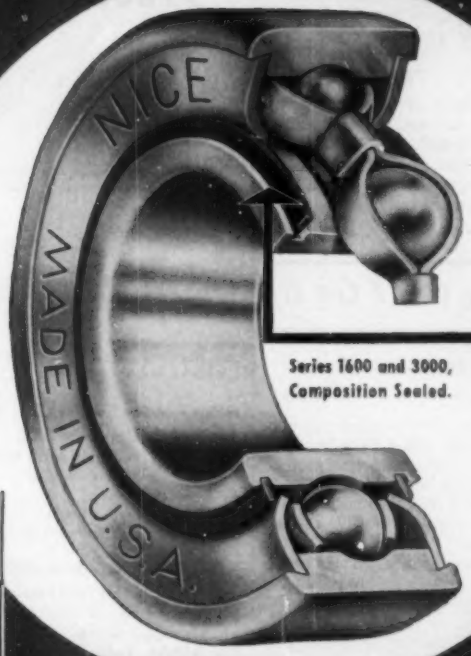
To the Editor:

In the December number of PRODUCT ENGINEERING, Messrs. Kendall and Byers discussed alleged "leaks" in the patent office. Coincidence of ideas has occasionally aroused suspicion of such leaks. Mr. Byers however explains the phenomenon by, "In the case of patentable inventions, when the prior art reaches a certain development, conception of further inventions is inevitable; and some of these inventions are identical in subject matter, although conceived by different parties."

Sixty years ago, Herbert Spencer remarked that, "Many have remarked the tendency that exists for an invention or discovery to be made by independent investigators nearly at the

field-tested and proven...

NEW!



Series 1600 and 3000, Composition Sealed.

COMPOSITION SEAL*
(OIL RESISTANT SYNTHETIC RUBBER COATED FABRIC)
*PATENT APPLIED FOR

ball bearings by

NICE

NICE "ground all over" close tolerance "1600" series bearings were especially designed to provide a line of low cost yet high quality bearings for adaptation to a majority of precision bearing applications. Series "3000" are relatively inexpensive unground radials of the same "precision type" construction.

Exhaustively field tested and proven highly successful, the NICE composition seal design effectively retains lubricant and excludes foreign material.

WRITE FOR NEW CATALOG NO. 140

NICE

NICE BALL BEARING COMPANY
NICETOWN PHILADELPHIA PENNSYLVANIA

THOMAS
Flexible ALL METAL COUPLINGS
FOR POWER TRANSMISSION REQUIRE NO MAINTENANCE

Patented Flexible Disc Rings of special steel transmit the power and provide for misalignment and end float.

Thomas Couplings have a wide range of speeds, horsepower and shaft sizes:
½ to 40,000 HP
1 to 30,000 RPM

Specialists on Couplings for more than 30 years

THE THOMAS PRINCIPLE GUARANTEES PERFECT BALANCE UNDER ALL CONDITIONS OF MISALIGNMENT.

NO MAINTENANCE PROBLEMS.

ALL PARTS ARE SOLIDLY BOLTED TOGETHER.

Write for the latest reprint of our Engineering Catalog.

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA

same time. There is nothing really mysterious in this. A certain state of knowledge, a recent advancement in science, the occurrence of some new social want—these form the conditions under which minds of similar characters are stimulated to like trains of thought, ending as they are prone to do in kindred results."

—C. O. SANDSTROM
Los Angeles, Calif.

Ed—The history of inventions points out literally thousands of examples of this sort of coincidence. We are glad that most of our readers recognize this point and expect to see similar ideas cropping up at about the same time.

Where Can I Get It

Magnetic Materials

To the Editor:

In your July 1949 number you published an article called "Soft Magnetic Materials" which summarized the materials available in a table. We are very interested in a number of these materials, particularly in Permendur, V-Permendur, and Hiperco. We should be very grateful if you would let us know whether they are available in sheet form, and if so who are the manufacturers.

—A. IVANOFF
Hayward-Tyler & Co. Ltd.

Ed—We suggest that you contact Allegheny Ludlum Steel Corporation, Brackenridge, Pa. for the magnetic materials Permendur and V-Permendur. For Hiperco, try the Westinghouse Electric Corporation, 306 Fourth Avenue, Pittsburgh, Pa. If these companies do not sell these soft magnetic materials, they can at least give you the needed information.

Waterproof Adhesive

To the Editor:

In the November 1949 issue, page 5, reference is made to a waterproof adhesive requiring neither heat nor pressure and suitable for cementing rubber, metal, cork, concrete, glass, wood, plastics, tile, asbestos, etc. On the basis of this information, it appears that this adhesive should be just about what has been urgently needed for such uses as cementing SR-4 gages as well as for a variety of other situations which, up to now, have been difficult to bridge satisfactorily in experimental work.

We hope that you may be able to supply literature and/or information

Here's how to anchor a cordset to an electrical appliance **to Increase Product Life**

Slip a HEYCO Nylon Strain Relief Bushing on wire. *(Heycos eliminate cord wear at chassis entrance.)*

Snap HEYCO into chassis hole. *(The Heyco imparts a positive non-slip grip; does not injure wire.)*

HERE'S WHAT A HEYCO WILL DO
1. Save time—reduce costs
2. Absorb cord pull, push and torque
3. Insulate wire at chassis
4. Prevent fraying
5. Eliminate tying knots
6. Improve appearance of product

HEYCOS ARE USED ON MANY PRODUCTS
You will find HEYCOS being used on an increasing number of nationally known appliances . . . toasters, heaters, clocks, roasters, mixers, record players, radios, television sets, toys, lamps, polishing machines, etc.

HEYCOS ARE MADE IN 11 SIZES
for clock wire to S-10/3 cable

APPROVED

MAKE SURE YOUR PRODUCT IS DOUBLY PROTECTED BY A HEYCO STRAIN RELIEF

HEYCO

HEYMAN MANUFACTURING CO.
KENILWORTH 3, N. J.

PRODUCT DESIGN STUDIES • NO. 16

FABRICATED POWER SHOVEL HANGER

CAST STEEL POWER SHOVEL HANGER

Cost Reduced 14%
Appearance Improved
Serviceability Improved
with STEEL CASTINGS

This power shovel hook roller hanger was originally produced as a weldment, weighing 214 lbs.

When the manufacturer's engineers, working with the steel foundry organization, analyzed costs, they found that the cost of a steel casting before machining was almost two and one-half times that of the material for the weldment. However, cost of assembly, welding, shearing, punching, rolling, and machining of fabrication was so much greater than cost of machining the casting that the *completed* cost of casting was 14% less than the completed cost of weldment!

Other advantages of the steel casting: More uniform distribution of imposed stresses, improved eye appeal, and 7% weight reduction.

• • •

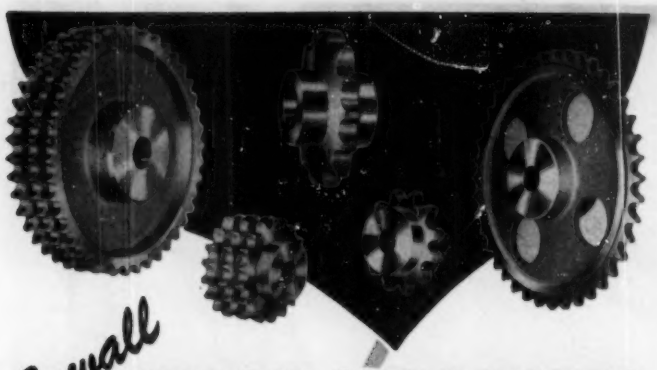
Conversion of some of *your* parts to steel castings may result in equal if not greater benefits than those given here.

Also in new and redesigned parts, your steel foundry engineer may be able to suggest ways to cut costs and weight and obtain other benefits. Why not call him in *while your product is still on the drawing board?*

This service is offered without cost or obligation. It makes available through your foundry engineer the full results of the development and research program of Steel Founders' Society of America.

STEEL FOUNDERS' SOCIETY OF AMERICA
920 Midland Building — Cleveland 15, Ohio

Design and Build With Steel Castings



Sewall STOCK SPROCKETS

★SPEEDY SERVICE
★COMPLETE LINE
★PRECISION BUILT

If your product will permit a standard pitch, look it up in the Sewall Catalog of Stock Sprockets. Or let us send you an estimate on your special design. True running, durable gears and sprockets all add up to over-all quality in Sewall products.

CUSTOM-BUILT GEARS for every requirement

I. B. SEWALL MANUFACTURING CO.
696 Glendale St. • St. Paul 4, Minn.

Send for FREE Sprocket CATALOG
or Phone Us at NEstor 1381

THE RIGHT BALL

Let Strom Help You

Not only in precision ball bearings, but in countless other places, Strom has found that the right ball will do the job better. Maybe your problem can be solved with the use of the proper ball. Why not take it up with Strom.

Strom has been making precision metal balls for over 25 years for all industry and can be a big help to you in selecting the right ball for any of your requirements. In size and spherical accuracy, perfection of surface, uniformity and dependable physical quality, there's not a better ball made.

Strom STEEL BALL CO.
1850 So. 54th Ave., Cicero 50, Illinois
Largest Independent and Exclusive Metal Ball Manufacturer

that will enable us to explore further the possibilities of this material for use in the type of situation outlined.

—H. J. GILKEY
Iowa State College

Ed—For full information contact Adhesive Products Corp., 1660 Boone Ave., New York 60, N. Y.

Lead Storage Battery

To the Editor:

Our attention has been drawn to an article which appeared in "Highlights" of the October 1949 issue of PRODUCT ENGINEERING and which briefly describes a lead storage battery having improved performance. As the Royal Canadian Air Force is interested in new developments along this line it would be greatly appreciated if further information or sources of information with regard to this battery could be forwarded.

Information in the nature of cost, availability, manufacturer and technical data is required.—A. G. SHEFFIELD
Royal Canadian Air Force

Ed—You should get complete details from Willard Storage Battery Co., Cleveland, Ohio.

Small Electron Tubes

To the Editor:

We would appreciate receiving more detailed information relating to small electron tubes with conducting walls which allows one beam of electrons to lower and control the potential in the space through which a second beam passes. This tube was described in the December 1946 issue of PRODUCT ENGINEERING.

—TRUMAN W. MALTBY
General Electric X-Ray Corp.

Ed—More information can be obtained from North American Philips Co., 100 E. 42nd St., New York 17, N. Y.

Help For Inventors

To the Editor:

In the December issue of PRODUCT ENGINEERING I noted a news item describing a new west coast agency set up to assist amateur inventors in marketing their inventions and gadgets.

I would very much appreciate knowing whether or not a similar agency exists here in the New York City area or other eastern city that performs a similar service for local inventors.

—EDWIN DREWITZ
Long Island City, N. Y.

Ed—You should contact the National Society of Inventors, Inc., Benjamin

PACKARD MOTORS

Your assurance of superior fractional horsepower performance

You can count on Packard fractional horsepower motors to provide top performance and dependable service. They will build customer good will . . . increase the value and trade acceptance of your products.

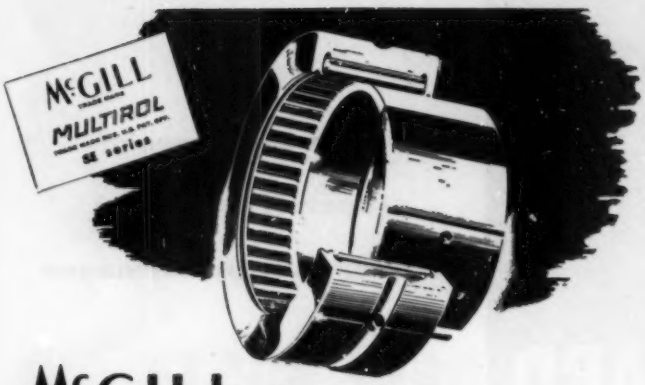
That is why more and more manufacturers of motor driven appliances and equipment are turning to Packard motors. They recognize Packard's outstanding performance record . . . a reputation for uniform *quality* manufacture—the result of 33 years devoted to the production of fractional horsepower motors.

Take advantage now of Packard's more than three decades of motor building experience. Specify Packard fractional horsepower motors for your products. They are your assurance of lasting satisfaction and superior performance!

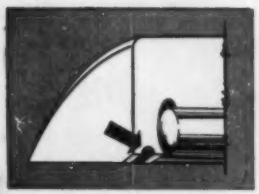
Packard GM
REG. U.S. PAT. OFF. TRADE MARK
GENERAL MOTORS

Packard Electric Division, General Motors Corporation, Warren, Ohio

DEPENDABLE APPLIANCE MOTORS FOR THIRTY-THREE YEARS



McGILL design
provides EXTRA oil seal protection



Extra protection against destructive foreign particles is provided by this lubricant-retaining groove, built into the inside diameter surface of the roller retaining-end shoulder. The ring of lubricant, held in this groove, acts against the inner race O.D., increasing the sealing effect of the precision tolerances between these shoulders and the inner race. Notice, too, the groove above the rounded end of the roller. Acting as a lubricant reservoir, this provides Multirol SE Series bearings with an extra margin of protection against neglected or delayed lubrication.

The increased life and lowered maintenance costs of Multirol bearings are accounted for by these built-in features, plus such design factors as greater load capacity and the elimination of loose or welded-in retaining rings. Multirol SE Series bearings, used with or without inner raceways in standard sizes of 5/8" to 9¼", are used extensively in machine tools, pumps, polishing machines, presses, power shovels, etc. — giving users a high degree of precision performance and longer bearing life.

Why not consult McGill engineers for helpful recommendations in applying these benefits to your product? Write McGill Mfg. Co., Inc., Bearing Division, 201 N. Campbell St., Valparaiso, Indiana. Ask for Bulletin SE-47.

McGILL
TRADE MARK
precision bearings

Franklin Station, Box 7410, Washington, D.C. This is the nearest and best society of its type that we know of to give you the help you want.

Polarizing Film

To the Editor:

In the December 1949 issue of PRODUCT ENGINEERING, in the Highlights section, you have mentioned a polarizing film which combs out infra red heat rays without the aid of large reflecting plates formerly required. I would very much appreciate a source from which I cannot obtain more specific information on this film.

—WILLIAM P. MURPHY, JR., M. D.
Peter Bent Brigham Hospital

Ed—Write the Polaroid Corp., Cambridge, Mass. for complete information.

Cast Polystyrene Sheet

To the Editor:

In your December 1949 issue of PRODUCT ENGINEERING, one item appears on page 3 which is of interest to us. This item concerns the properties of cast polystyrene sheet, (last paragraph), as compared with properties of methyl methacrylate. Will you please arrange to have sent to us any further information on this material, including data sheets, et cetera.

Your cooperation is appreciated.

—A. M. McGEEHIN
E. I. Dupont de Nemours & Co.

Ed—You should write Cast Optics Corp., 115 Jericho Turnpike, Mineola, N. Y. for full details.

Electrofilm Process

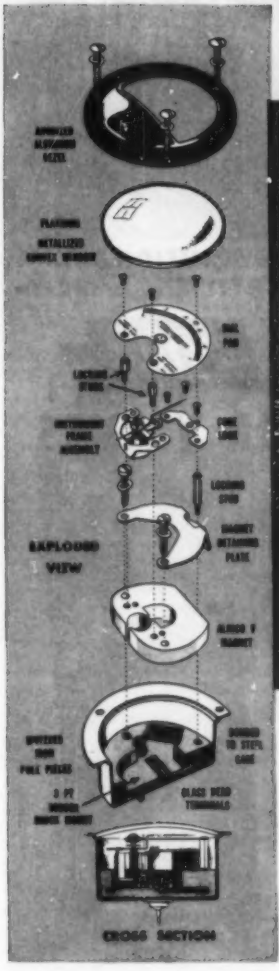
To the Editor:

In the December 1949 issue of PRODUCT ENGINEERING, a paragraph on page 7 of the Highlights section is devoted to a description of tests on an "Electrofilm Process". It is understood that this process, which involves a graphite coating of pistons by spraying and then baking, shows promise of being a superior dry lubrication technique.

I am very interested in obtaining further information on the subject and would appreciate your forwarding the name of the company which handles this work, or the source of more detailed information. —R. F. DYER
Tennessee Eastman Corp.

Ed—The Electrofilm Corporation, North Hollywood, Calif. should be able to provide full information on this interesting new dry lubrication technique.

Exceeding Expectations!



NEW marion *ruggedized* meter

Marion Ruggedized Meters introduce a brand new family of panel instruments produced to give outstanding performance under *extreme* conditions of Shock . . . Vibration . . . Mechanical Stress or Strain. Hermetically sealed, they are impervious to the weather conditions of *any* climate.

Marion Ruggedized Instruments give you new freedom of application. They are extremely accurate, highly sensitive meters that may be used in places where no one has ever before *dared* use "delicate instruments." Count on them to exceed your greatest expectations in *any* application.

Send for your free copy of our booklet on the new Marion Ruggedized Meters today. See how Ruggedized Meters meet the dimensional requirements of JAN-I-6 and are interchangeable with existing standard JAN 2½" and 3½" types. Learn why their electrical and mechanical performance far *exceeds* existing JAN requirements. Discover for youself some of the developments that made the ruggedized meter possible.

Manufacturers of Hermetically Sealed Meters Since 1944

MADE BY THE MAKER WHOSE NAME MEANS THE MOST IN METERS

M·E·I

MARION ELECTRICAL INSTRUMENT COMPANY

MANCHESTER, NEW HAMPSHIRE

Export Division, 458 Broadway, New York 13, U.S.A., Cables MORHANEX
In Canada: The Astral Electric Company, Scarboro Bluffs, Ontario

1

SOURCE FOR ALL PARTS YOU NEED

LOCK WASHERS

High carbon steel, bronze, aluminum, stainless steel, monel metal, spring lock washers . . . finished or plated with cadmium, nickel, brass or copper. Also Garrett's Aluminum Spring Lock Washer—light in weight with strength of steel.

FLAT WASHERS

Made to meet ASA and SAE specifications in regular steel spring steel, stainless steel, brass, bronze, monel metal, aluminum, Alclad and copper. Can be plated with zinc, cadmium, nickel, brass, chrome . . . or can be parkerized.

STAMPINGS

From a small part for electronic instruments, automotive stampings and television chassis... Garrett can fabricate them better and cheaper than is possible in your own plant. Years of experience and modern high speed equipment assure speed deliveries . . . finished to your specifications.

SPRINGS

Flat and coiled springs to meet every requirement. Every Garrett spring has controlled tension built into it to assure satisfactory performance under all conditions. All types of flat springs . . . coil springs — compression, extension . . . made of round, square or rectangular wire.

MANUFACTURED BY
GEORGE K. GARRETT CO., INC.
PHILADELPHIA 33, PA.

GARRETT
MANUFACTURERS OF SMALL PARTS

MEETINGS

February 20-21
SECOND ANNUAL PURDUE MATERIALS HANDLING CONFERENCE, Purdue University, Lafayette, Ind.

February 27-March 3
AMERICAN SOCIETY FOR TESTING MATERIALS—Committee Week and Spring Meeting; Hotel William Penn, Pittsburgh, Pa.

March 14-16
SOCIETY OF AUTOMOTIVE ENGINEERS—Passenger Car, Body and Production Meeting, Book-Cadillac Hotel, Detroit, Mich.

March 21-22
STEEL FOUNDERS' SOCIETY OF AMERICA—Annual Meeting, Chicago, Ill.

March 28-31
SOCIETY OF THE PLASTICS INDUSTRY—National Plastics Exposition; Navy Pier, Chicago, Ill.

April 4-7
NATIONAL ASSOCIATION OF CORROSION ENGINEERS—Annual Conference and Exposition, St. Louis, Mo.

April 10-14
AMERICAN SOCIETY OF TOOL ENGINEERS—Industrial Exposition on Cost Cutting, Convention Hall, Philadelphia, Pa.

April 12-14
AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Spring Meeting, Hotel Statler, Washington, D. C.

April 17-19
SOCIETY OF AUTOMOTIVE ENGINEERS—Aeronautic and Aircraft Engineering Display, Hotel Statler, New York.

April 24-26
AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Process Industries Division Conference, Hotel William Penn, Pittsburgh, Pa.

April 24-27
AMERICAN MANAGEMENT ASSOCIATION—19th National Packaging Exposition, Navy Pier, Chicago, Ill.

April 25-26
METAL POWDER ASSOCIATION—Annual Metal Powder Show, Book-Cadillac Hotel, Detroit, Mich.

May 5-6
AMERICAN PHYSICAL SOCIETY—National Meeting and Midwestern Conference on Fluid Dynamics, University of Illinois, Urbana, Ill.

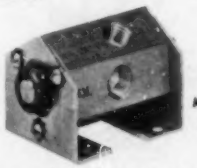
NOW! ABSOLUTE CONTROL OF AIR POWER

REVOLUTIONARY, BECKETT-ENGINEERED

HI-CYCLIC

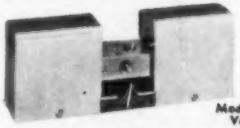
AIR VALVES

Entirely new air valve gives complete control of air cylinder action! New Hi-Cyclic Air Valve functions same as ordinary operating valve—PLUS—controls stroke of air cylinder to .001"; reciprocates mechanically or electrically; controls pressure in both ends of cylinder; stops and returns stroke at any point without over-travel; controls stroke speed in either direction; effects a tremendous saving in air; maintains smooth, hydraulic-like action at all speeds. Operates on pressures as low as 1 P.S.I. Also operates on vacuum. Opens up *unlimited* applications for accurate, fast, smooth control for air-powered, labor-saving machinery. Write for details and recommendations. Ask for Bulletin 10.



Model B Basic Valve

2, 4 or 5-way valve in 1/8", 1/4" and 3/8" sizes. Small, compact. Gives complete control of air cylinder action. Also is reciprocating valve capable of 2500 cycles per min.



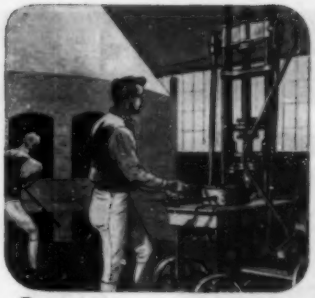
Model B-2 Valve

3 or 4-way valve in 1/4", 1/4" and 3/8" sizes. Dual solenoids actuated by momentary contact—no complex switching controls. Makes possible any desired action. Controls stroke to .001".

Also available: single solenoid spring return valves, 1/8", 1/4", 3/8"—heavy-duty piloted valves, single and double solenoid, 1/2", 3/4", 1"—hydraulic valves, single and double solenoid, 1/8", 1/4", 3/8".

BECKETT-HARCUM CO.
1141 Wayne Rd.,
Wilmington, Ohio

1 **1621**—Glass was money! America's first glass factory was actually a mint—not for the manufacture of coins but to make glass beads for *use* as money when buying land, food and furs from the Indians.



2 **1827**—Blown glass was the rule until Enoch Robinson, a carpenter, figured glass could be *pressed* into shape . . . the glass pressing machine was born. Electricity to power new machines was still to come.

3 **1899**—Owens invented a machine to make bottles as the machine age arrived in glass. By 1915, Howell "Red Band" Motors were making important contributions to this and other industries.

ANOTHER HOWELL SUCCESS STORY

GLASS...from artisans to automatic machines

4 **Today**—Modern, electrically driven machines have improved quality, cut costs and increased output in the glass making industry. For example, this unique glass beveling machine, equipped with 7 dynamically balanced Howell Motors, *automatically* bevels glass at the rate of 2,000 inches per hour!

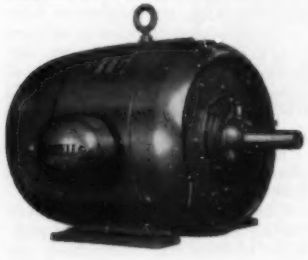
You'll also find precision-built Howell Industrial Type Motors powering bottle and bulb machines, conveyors, grinders, polishers, plate and window machines in the glass industry.

Elsewhere, Howell's wide range of standard NEMA motors, and special motors designed to customer requirements, serve dependably and efficiently under the toughest conditions.

For a really profitable investment, buy HOWELL!

Free enterprise encourages mass production, supplies more jobs—provides more goods for more people at less cost.

Howell totally enclosed, fan-cooled motor—windings completely sealed against dirt and weather.



HOWELL MOTORS

HOWELL ELECTRIC MOTORS CO., HOWELL, MICH.

Precision-built Industrial Motors Since 1915

HOWELL Red Band MOTORS

10 YEAR SWITCH

New Different

Prices Reduced 28% to 55% on same capacity

- ★ Twice capacity of older models
- ★ Hydrogen pressure increased
- ★ No sputtering or false contacts
- ★ No deterioration from inactivity
- ★ Withstands higher temperatures
- ★ Lower operating angles

5 New Models
ask for BULLETIN 525

KEEPS COOL UNDER PRESSURE

NEW and IMPROVED

Steel **Durakool**
MERCURY SWITCHES and RELAYS

DURAKOOL, INC., 1010 N. MAIN ST., ELKHART, INDIANA
IN CANADA: CONTROLITE ENG. & SALES, LTD., TORONTO 5, ONTARIO

IF IT'S IRON OR STEEL

REMEMBER to have it HOT DIP GALVANIZED

(DIPPED IN MOLTEN ZINC)

For a top quality job of genuine hot-dip galvanizing, send your materials to one of the galvanizers listed at the right. They are all members of the American Hot Dip Galvanizers Association and are pledged to adhere rigidly to its specifications for hot-dip galvanizing.

ALABAMA
THE LERIO CORPORATION, MOBILE
METALPLATE COMPANY, BIRMINGHAM

CONNECTICUT
WILCOX, CRITTENDEN & CO., INC., MIDDLETOWN

GEORGIA
ATLANTIC STEEL COMPANY
P. O. BOX 1714, ATLANTA

ILLINOIS
EMPIRE METAL PRODUCTS COMPANY, CICERO
EQUIPMENT STEEL PRODUCTS, BLUE ISLAND
JOSLYN MFG. & SUPPLY CO., CHICAGO
STANDARD GALVANIZING CO., CHICAGO

MARYLAND
SOUTHERN GALVANIZING CO., BALTIMORE

MICHIGAN
RIVERSIDE FOUNDRY & GALV. CO., KALAMAZOO

MISSOURI
COLUMBIAN STEEL TANK CO., KANSAS CITY
MISSOURI ROLLING MILL CORP., ST. LOUIS

NEW JERSEY
L. O. KOVEN & BROTHER, INC., JERSEY CITY
INDEPENDENT GALVANIZING COMPANY, NEWARK

NEW YORK
JEFFERSON UNION COMPANY, INC., NEW YORK
THE THOS. GREGORY GALV. WORKS, MASPETH

OHIO
ARMCO STEEL CORPORATION, MIDDLETOWN
THE FANNER MFG. CO., CLEVELAND
NATIONAL TELEPHONE SUPPLY CO., CLEVELAND
THE WITT CORNICE COMPANY, CINCINNATI
COMMERCIAL METALS TREATING, INC., TOLEDO

PENNSYLVANIA
LEHIGH STRUCTURAL STEEL CO., ALLENTOWN
PHILA. RANGE BOILER & TANK CO., COATESVILLE
COLUMBIA MALLEABLE CASTINGS CO., COLUMBIA
AMERICAN TINNING & GALVANIZING CO., ERIE
HAMLON-GREGORY GALV. CO., PITTSBURGH
OLIVER IRON & STEEL CORP., PITTSBURGH
PENN GALVANIZING COMPANY, PHILADELPHIA

TENNESSEE
COMBUSTION ENGINEERING-SUPERHEATER, INC., CHATTANOOGA
M. M. HEDGES MFG. COMPANY, INC., CHATTANOOGA
NOLAND TANK AND GALVANIZING COMPANY, NASHVILLE

TEXAS
DALLAS IRON & WIRE WORKS, INC., DALLAS

WISCONSIN
ACME GALVANIZING, INC., MILWAUKEE

NEW BOOKS

Applied Mechanics

ALFRED P. POORMAN, *A.B., C.E., Professor Emeritus of Engineering Mechanics, Purdue University. Published by the McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 18, N. Y. Fifth Edition, 388 pages, 5½ x 8 in.* $4.

With the printing of this, the fifth edition, *Applied Mechanics* goes into its thirty-second year of publication. Intended as a fundamental text for an engineering undergraduate course in Mechanics, it contains sections on both statics and dynamics.

The section on statics is broken down into ten chapters. Chapter I is devoted to the development of definitions and general principles, including classification of forces, transmissibility of forces, homogenous equations, and other basic discussions. Chapter II, which is devoted to coplanar, concurrent forces, contains a definition of such forces and sub-sections on the graphical representation of forces, the graphical resultant of two forces, the resolution of a force into components, the trigometric resultant of two forces, the algebraic resultant of two forces, the resultant of three or more forces, the moment of a force with respect to a point, Varignon's theorem of moments, graphic solution of equilibrium of three or more forces, trigonometric solution of equilibrium of three or more forces, and algebraic solution of equilibrium of three or more forces by summation of forces and by moments.

The remaining chapters in this section are treated in as great or greater detail. These chapters include discussions of coplanar parallel forces, coplanar nonconcurrent forces, concurrent forces in space, parallel forces in space, nonconcurrent nonparallel forces in space, friction, centroids and centers of gravity, and moments of inertia of areas.

Under the section on dynamics, Part II of the book, are chapters on kinematics of a particle; kinetics of rigid bodies in rectilinear translation; moments of inertia of masses; rotation of rigid bodies; any plane motion of rigid bodies; work, energy, and power; and impulse, momentum, and impact.

There are, in total, 175 basic principles developed and discussed in the book.

Changes in material in the new edition include: (1) numbering of problems consecutively throughout the

IF YOU BUY OR SPECIFY SPRING STEEL

This Free Book Belongs On Your Desk

- ***Catalogues 785 different sizes of Sandvik's specialized, cold-rolled spring steel.***
- ***Contains 133 cold-rolled and bright annealed sizes and 652 cold-rolled hardened and tempered sizes.***

This helpful 8½ x 11 catalog gives you quick and easy reference to Sandvik's line of specialized spring steels.

You get complete information on each size, at a glance. For instance, the Cold Rolled and Bright Annealed section gives you the thickness, width, degree of hardness, type of edges and weight in pounds per hundred lineal feet for each size. In the section on Hardened, Tempered and Polished Spring steels the thickness, width, finish, edges and weight per hundred feet is shown.

The booklet also includes such useful reference tables as Weights of Strip Steel, Comparative Table of Wire Gauges, Numerical Conversion Tables, Hardness Conversion Tables and a Temperature Conversion Table.

In addition, the catalog gives background information about Sandvik and the reasons behind Sandvik steel's quality. It lists some of the specialized applications for which these steels are used and tells what information to give when inquiring or ordering.

Have this complete, easy-to-use spring steel catalog at your fingertips. A note on your letterhead will bring it to you promptly and without obligation.

SANDVIK STEEL, INC.

114 EIGHTH AVE., NEW YORK 11, N. Y., WAtkins 9-7180
183 N. Michigan Ave., Chicago 1, Ill., FRanklin 2-1745
1739 Columbus Rd., Cleveland 13, O., CHerry 2303
Warehouses: New York and Cleveland
SANDVIK CANADIAN LTD.
426 McGill St., Montreal, Canada

S3-51

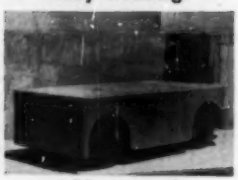
For greater safety under foot,
in your plant and on your products

Inland 4-Way Safety Plate®

Safe Footing

Easy Cleaning

Firesafe



Adds Strength

INLAND

INLAND STEEL COMPANY, Dept., PE2G
38 So. Dearborn St., Chicago 3, Ill.
Sales Offices: Chicago, Davenport, Detroit, Indianapolis, Kansas City, Milwaukee, New York, St. Louis and St. Paul.

New Bulletin with New Ideas—Just Out! Bulletin F1. Complete engineering and application data. Send for it!

STOCKED BY LEADING STEEL WAREHOUSES

book, including those for which solutions are given, thus making cross references between problems much simpler; (2) addition of problems following the articles that contain the principle that the problem is intended to illustrate; (3) loads on structures are given in kips instead of in pounds; (4) a treatment of the supplementary acceleration of bodies in plane curvilinear motion as given by the law of Coriolis; and (5) addition of a table of moments of inertia and radii of gyration of a number of simple areas to the chapter on Moments of Inertia of Areas.

Making Patent Drawings

HARRY RADZINSKY, *Patent Attorney. 96 pages, 7½x10¼ in., published by the Macmillan Co., 60 Fifth Ave., New York.* $3.

This book is written to explain how to become proficient in making patent drawings. It discusses general drafting technique and relations between the patent draftsman and inventor as well as special drafting techniques required for patent work.

The book explains some of the reasons for the differences between patent drawings and ordinary working drawings. The patent drawing is supposed to show the novel features completely enough so a skilled mechanic could construct the device and clearly enough to minimize controversy. In addition, the drawings should be easy to read and concise. Finally, they must conform to the rules of the patent office.

Shading and insertion of reference characters is explained in considerable detail. The principles involved in deciding what to show, what views to draw, and how to plan the drawing are discussed. Patent office rules relative to drawings are given. Reasons for the rejection of patent drawings are given.

The book is well illustrated with samples of patent office drawings.

Materials Engineering Of Metal Products

NORMAN E. WOLDMAN, *Consulting Metallurgical Engineer; Ph.D., Professor, Cooper Union School of Engineering and Stevens Institute of Technology Graduate School. 583 pages, 6 x 9 in. Published by Reinhold Publishing Corp., 330 W. 42nd St., New York, N. Y.* $10.

This volume was written as a companion book to "Metal Process Engineering," published by Reinhold early in 1948. The latter book was concerned with the different metallurgical

AFTER 20 MILLION STROKES THESE LINEAR "V" RINGS WERE STILL GOING STRONG!

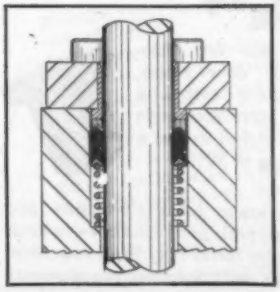
Another Proof-of-the-pudding Demonstration of LINEAR "V" RING Efficiency

This unretouched photograph shows a cut-away section of one of 3 sets of LINEAR "V" Ring packings. Each set was installed at 6-month intervals in a vertical triplex pump operating continuously for a year and one-half under actual service conditions. Throughout the entire 18-month period no maintenance or adjustments were required. When removed, each set was sealing as efficiently as when first installed . . . *and most important, all three sets had identical wear characteristics.*

Spring-loading the packing changed this installation from an adjustable gland to a fixed gland bolted metal-to-metal, thus providing automatic take-up to the packing installation. The result? Complete elimination of dangerous over-tightening of the packing and greatly improved seal life.* By using a spring-loaded installation with style M90 "V" Rings (specified for excellent abrasion resistance) a uniform and predictable packing life was determined from one installation to the next.

LINEAR offers industry a complete line of fabric reinforced and homogeneous "V" type packings for every service. They operate automatically from zero to peak pressures against air, steam, water, gas, oils and solvents over a wide temperature range.

For lowered packing costs and sealing devices of proven dependability, CALL LINEAR.



***PROGRESS REPORT OF SIX-MONTH SERVICE TEST:**

TYPE OF EQUIPMENT: Vertical Triplex Pump.

ROD MATERIAL: Cold drawn Monel.

FLUID PUMPED: River water containing solids of seven grains per gallon.

PACKING: Fabric top adapter with 5 pressure rings homogeneous type (LINEAR M90-V).

METHOD OF INSTALLATION: Packing set used with machined metal adapter installed with a coiled spring with a compression of 5 lbs. per inch of mean circumference for the spring load.

SPEED: 144 four-inch strokes per min.

HIGH PRESSURE: 10,108,980 strokes at 2250 psi.

LOW PRESSURE: 10,108,980 strokes at 0 psi.

TOTAL STROKES: 20,217,960.

"PERFECTLY ENGINEERED PACKINGS"

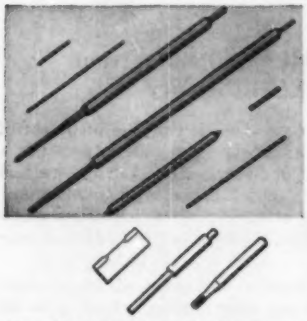
LINEAR

LINEAR, Inc., STATE ROAD & LEVICK STREET, PHILADELPHIA 35, PA.

SAVE

on metal parts made to your prints by

TORRINGTON

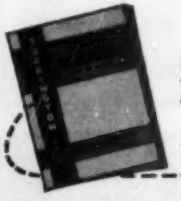


Special equipment and volume production enable us to save for you on a wide variety of precision metal parts.

For example, special shafts and pivots are made to order for meters, instruments, speedometers, tachometers, etc. Sharp, concentric, ground or swaged single or double points. Diameters .015" to 5/16". Lengths 3/16" to 10".

Send your prints and specifications today for a prompt quotation, and ask for a copy of "Precision Metal Parts".

THE TORRINGTON COMPANY
Specialty Department
554 Field Street • Torrington, Conn.



Send coupon today for your free copy of this booklet.

Name_____

Firm_____

Address_____

_____ 4

and mechanical processes for fabricating metal parts such as casting, forging, rolling, powder metallurgy, joining of metals, heat treatment and machining of metals.

The author presents the materials used in vaious types of industries and different applications in an attempt to correlate the metallurgy of the material with engineering design and service applications. It has been written to meet the needs of engineering students, professional engineers and production engineers, as well as for writers of materials specifications, industrial designers and metallurgical engineers, all of whom can use the correlated and interpreted information in part or as a whole in their professional work.

There are five main sections: (1) Materials for Light-weight Construction, such as aluminum alloys, magnesium alloys, high strength-low alloy steels and stainless steels; (2) Materials for Mechanical Products, such as gears, springs, bearings and threaded fasteners; (3) Materials for Electrical Industries, such as magnetic materials, electrical contacts, thermostat metals, and electrical resistance alloys; (4) Materials for Special and Severe Service, such as corrosion-resistant materials and high-temperature alloys; and (5) Testing of Materials, such as mechanical testing and non-destructive testing. An Appendix of tabulated properties and characteristics of materials is included.

The Economics Of Industrial Management

WALTER RAUTENSTRAUCH *and* RAYMOND VILLERS, *Consultants in Industrial Management, Members of the Faculty, Department of Engineering, Columbia University.* 450 *pages,* 6 x 9 *in. Published by Funk and Wagnalls Company, in association with Modern Industry Magazine, New York,* $5.

Any engineer who frequently has to make decisions based on the economics of alternative solutions will find this book to be of great value. Over 20 years ago Dr. Rautenstrauch originated the Break-Even Chart. In this latest edition, the newest developments of the Break-Even Chart procedures are described. There are applications of the technique to many types of industrial problems.

The book also covers the fundamental principles of Profit and Loss statements, the principles of costs classification, and the allocation of costs. While, no doubt, all engineers are familiar with the Break-Even Chart, it is probably equally true that few of them realize the many things

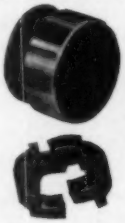
YOU BET! IT'S WEL-MET

for better service on

METAL POWDER Machine Parts

We're big enough to handle large volume orders—yet small enough for our top executives and engineers to be "in on" every job going through our plant.

This farm tractor throttle was designed to take advantage of the excellent frictional properties of sintered steel and bronze. Cost is very low, too.



V-belt driven centrifugal clutch assembly features low manufacturing cost and unequalled frictional properties.

Ratchet for automatic door closer, formerly cast and machined, now made of sintered iron at a saving of 50%.

For lower fabrication costs and improved performance — check powder metallurgy. Send your blueprints and production requirements to . . .

The WEL-MET Company
141 DOUGLER AVENUE
KENT, OHIO

SQUARE D's *New*

SAFETY SWITCHES

*Types A, C and D

Backed by 40 years' DESIGN LEADERSHIP

The remarkable superiority of this new switch line is reflected in these TYPE A design and operating features:

MODERN STYLING is both functional and attractive.

COMPACTNESS obtained without sacrifice of wiring convenience.

FULL COVER INTERLOCK has attachment that locks switch "ON" or "OFF" with 1, 2, 3 or 4 padlocks of nearly any size or shape.

SIMPLE MECHANISM—quick make-and-break action—no dead center.

SILVER-PLATED current-carrying parts.

EXPOSED BLADES permit visual checks of switch operation.

DEAD-FRONT line terminals are protected by hinged arc chamber cover.

MAGNETIC ARC PLATE adds to unusually high rupturing capacity.

POSITIVE PRESSURE jaws and fuse clips, steel reinforced, silver-plated.

NON-TRACKING insulation used in base. Melamine insulating cross-bar.

REMOVABLE PRESSURE CONNECTORS permit substitution of solder lugs, where preferred.

**Types C and D similar to Type A in appearance—differ in construction details*

NOW in production: 30, 60, 100 and 200 ampere sizes

Write for Bulletin 3100 • Square D Company, 6060 Rivard Street, Detroit 11, Michigan

SQUARE D COMPANY

DETROIT · MILWAUKEE · LOS ANGELES

SQUARE D COMPANY CANADA LTD., TORONTO • SQUARE D de MEXICO, S.A., MEXICO CITY, D.F.

For more efficient Heat Transfer ...
Investigate
FINNED TUBING BY BUSH
Here is the modern answer to your every heat transfer engineering problem . . . the most efficient and economical development in heating and cooling design. Let Bush expert engineers . . . backed by more than forty years of experience in this highly specialized field . . . in one of the largest and most up-to-date factories in the industry . . . and in conveniently located field offices . . . consult with you in the selection and application of the type of Bush Finned Tubing exactly suited to your particular requirements.
Write today for Bush FINNED TUBING SPECIFICATION SHEETS. Address Dept. C5 WEST HARTFORD 10, CONN.
Bush
HEAT TRANSFER PRODUCTS
BUSH MANUFACTURING CO.
Buy the Best-and the Best is Bush

that can be studied by the application of this technique. Indeed, it is likely that the author, himself, has by no means exhausted the possibilities of Break-Even Charts as applied to problems in design and production engineering. Where the engineer or the management is faced with the choice of production methods or different design constructions, these graphical methods have an almost untouched field of possibilities.

Numerical Analysis of Heat Flow

G. M. DUSINBERRE, *professor of mechanical engineering, Pennsylvania State College.* 227 *pages,* 6x9 *in. Published by The McGraw-Hill Book Co.,* 330 *W.* 42*nd St., New York* 18, *N. Y.* $4.50.

In this volume are presented the several numerical methods for calculating the flow of heat within solid bodies and across their boundaries. In these methods, the materials that contain the heat flow system are represented by a finite network of points, and solutions are obtained by a finite-difference treatment. These finite-difference methods are free from many of the limitations of conventional differential analysis. The author demonstrates in this volume the use of a method that the reader will find useful in many fields of engineering and physics.

A variety of techniques is presented, from which the reader can select one, or combine with several, to apply in attacking specific heat conduction problems as they are encountered, whether in the field of steady state or transients.

To give the reader practice and exercise in developing methods of procedure, many problems are included. To supplement the text and for further study, a bibliography lists more than fifty works and papers.

In this book the author has developed methods of calculation by which practicing engineers can get the final numerical result that is needed for intelligent planning.

Machinery's Handbook

ERIC OBERG AND F. D. JONES. *Fourteenth Edition,* 1911 *pages,* 4¼ x 6¾ *in. Published by the Industrial Press,* 148 *Lafayette St., New York* 13, *N. Y.* $7.

Since its first publication in 1914, MACHINERY HANDBOOK has been found quite valuable as a reference for the metalworking industries. It is particularly good on practical shop information, somewhat light on practical design data except as concerns mechanics, materials, and some mechani-

Smooth Power

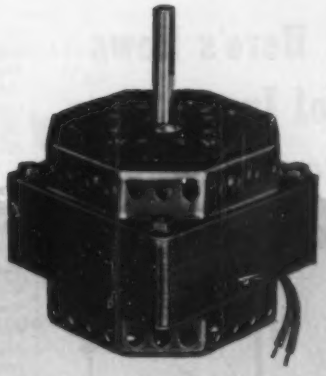
for small motor applications

- Kitchen Fans
- Radio-Phonographs
- Business Machines
- Furnace Controls
- Action Displays
- Sound Recorders

There's a full measure of dependable, long-lasting *Smooth Power* in each of these famous GI motors—1/70th H.P. and under. Built to rigid performance standards, they incorporate the same advanced features—including dynamic balancing of every rotor—which have long distinguished all General Industries products throughout the radio-phonograph industry.

All models are available for either clockwise or counter-clockwise rotation, with additional design modifications available where quantities warrant production line changes.

For blueprints and quantity price quotations, write, wire or phone *today*.

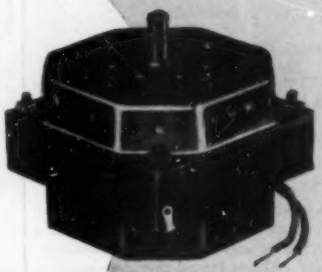


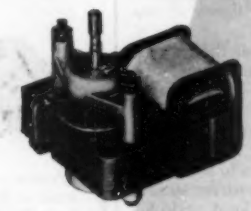
MODEL D-10 (1/70 H. P.)

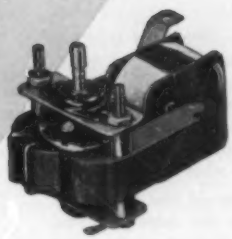
4-pole, shaded pole induction motor. Free Speed—1740 R.P.M. Locked Rotor Torque—4¾ in. oz.—H.P. at 1500 R.P.M. —1/70; Dimensions: 3⅛" square x 3⅛" over bearing housings. Features include scientifically designed air intake . . . dual cooling fans . . . dynamically balanced rotor . . . self-aligning oiless sleeve bearings.

MODEL D-6 (1/100 H. P.)

4-pole, shaded pole induction motor. Free Speed—1735 R.P.M. Locked Rotor Torque—2¼ in. oz. — H.P. at 1400 R.P.M. — 1/100; Dimensions: 3⅛" square x 2⅝" over bearing housings. Features include dual cooling fans . . . dynamically balanced rotor . . . self-aligning, oiless sleeve bearings.







MODEL A-5 (1/250 H. P.)

2-pole, shaded pole induction motor. Free Speed — 3470 R.P.M. Locked Rotor Torque—1.2 in. oz.—H.P. at 2800 R.P.M. —1/250; Dimensions: 2½" wide x 3 5/32" long x 2¼" high. Features include novel bearing construction which insures rigid and permanent alignment of motor shaft . . . oiless bearings . . . dynamically balanced rotor.

MODEL C-5 (1/300 H. P.)

2-pole, shaded pole induction motor. Free Speed — 3370 R.P.M. Locked Rotor Torque — 0.9 in. oz. — H.P. at 2600 R.P.M. —1/300; Dimensions: 2" wide x 3½" long x 2 7/32" high. Features include accurately aligned motor shaft . . . oiless bearings . . . dynamically balanced rotor.

The GENERAL INDUSTRIES Co.

DEPARTMENT D • ELYRIA, OHIO

Here's News of Importance to All Quantity Users of Springs

IF you are a user of large quantities of precision springs of any type we have a proposition that may very well result in a substantial reduction in costs for you. All we ask is the opportunity to have our engineers go over your spring requirements. Our experience indicates that the application of our "know-how" and modern facilities can often result in lower costs through improved manufacturing methods.

Good examples of our ability to save important amounts of money for our customers are the springs sketched above. In each of these, improved forming methods developed by Accurate reduced costs to a fraction of what they had been.

Now, we would like the opportunity to do the same for you. There's no obligation on your part so write today.

Accurate Springs

COST CONSCIOUS QUALITY
Since 1930

ACCURATE SPRING MFG. CO.
3815 W. Lake St. • Chicago 24, Ill.
Springs, Wire Forms, Stampings

cal components. In this respect, it is a competitor not of Mark's Mechanical Engineering Handbook, but rather of the new Tool Engineer's Handbook, edited and authored by a committee of the American Society of Tool Engineers and published by McGraw-Hill.

The book is divided into fourteen sections as follows: mathematical tables, including powers, roots, reciprocals, circumference, and areas of circles, surface and volume of spheres, and other basic data; logarithm tables; trigonometric tables; mechanics; strength of materials; gearing; bolts and screws; screw threads; limit gages; small tools; cutting speeds and feeds; steels and alloys; electric motors, and weights and measure.

According to the publisher, this new edition "covers a large variety of subjects that are important to designers and builders of everything mechanical. Recent or revised engineering standards are included, together with a large amount of general information and mechanical data representing the latest designing and manufacturing practice."

Basic Theories of Physics

PETER GABRIEL BERGMAN, *Associate Professor of Physics, Syracuse University.* 280 *pages,* 5½ x 8½ *in. Published by Prentice-Hall, Inc.,* 70 *Fifth Ave., New York, N. Y.* $5.

The author has presented in this book the theoretical foundations of "classical" physics, that is Newton's mechanics and Maxwell's electrodynamics, and has traced this development through to the special theory of relativity.

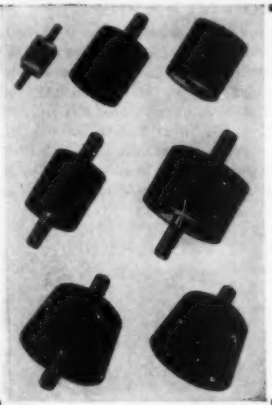
In the organization of the material, he has attempted to concentrate attention on physical ideas and to relegate the mathematical techniques to the role of tools. Since the tools are not generally available to the student in the stage at which he begins to study theoretical physics as a separate subject, discussions of variational calculus, vector and tensor calculus, and Fourier analysis are scattered through the book. While much can be said for the method initiated by Joos, to preface the main body of the text by an introduction to these mathematical methods, he considers it preferable to get started with the physics right away and to introduce mathematical discussions only when they are needed and when it is possible to motivate the diversion by its obvious necessity. In the selection of physical subjects, he has been guided by the importance that they have for an understanding of modern physics and has included a discussion of Hamilton-Jacobi's partial differential equation, because of its historical relation-

VIBRATION PROBLEM?

INVEST $2.00
SAVE $200.00!*

Protect Your Equipment With "FINNFLEX" STUD TYPE Vibration Isolators

*For an investment of $2.00 to $5.00 per machine, you can save HUNDREDS or even THOUSANDS of DOLLARS on your new equipment (case histories on file).



"FINNFLEX" Stud Type Vibration Isolators have 54 load ranges of 1 lb. to 270 lbs. each. Rubber is bonded to metal, and has a breaking strength 15 times the working load. Isolator designs are essentially the same varying in dimension and rubber stiffness only. Cost is low! Write for prices!

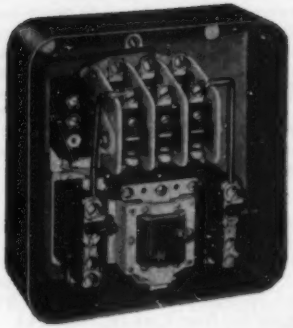
Equipment which can use these Stud Type Isolators to reduce noise are:

Small Motors, Fans, Blowers, Compressors, Generators, Pumps, Engines, Lathes, Grinders, Radios, Refrigerators, Gages, Scales, Switches, Panel Boards, Transformers, Air Conditioning and Ventilating Equipment Neon, Fluorescent Lighting, Timing and other Sensitive Instruments.

In addition to stud type mounts, we have many other types of Vibration Mounts, to solve any type of vibration problem.

Write for Descriptive Literature!

FINN & CO.
2852—8 Ave., New York 30, N.Y.



Specify

HONEYWELL

MOTOR STARTERS AND CONTACTORS

. . . For Long-Life and Trouble-Free Operation

HONEYWELL Motor Starters and Contactors are compact and sturdy . . . built to "take it" under the most severe conditions . . . and are ideal for control panel operation.

They'll deliver the sure-fire reliability that means continuous, trouble-free performance . . . that keeps operators happy and processes on the beam. So, specify Honeywell and be sure . . . the next time you need Starters or Contactors.

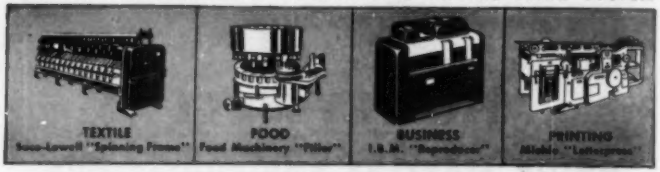
Your local Honeywell engineer is as near as your phone. Call him in today for detailed information . . . or write for descriptive Bulletin SA 1450.

COMMERCIAL · RESIDENTIAL · INDUSTRIAL
WORLD'S LARGEST ORGANIZATION FOR ADVANCED INSTRUMENTATION AND CONTROL

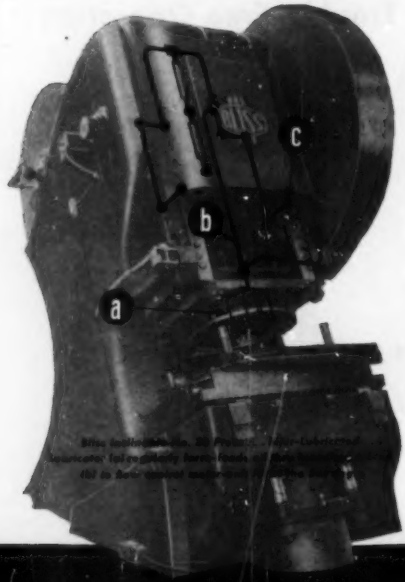
MINNEAPOLIS-HONEYWELL REGULATOR CO.
BROWN INSTRUMENTS DIVISION
4459 Wayne Ave., Philadelphia 44, Pa.
Offices in 77 principal cities of the United States, Canada and throughout the world

Honeywell — *Advanced Instrumentation* FOR BETTER PROCESSING — BROWN

LEADING MANUFACTURERS STANDARDIZE ON THE BIJUR SYSTEM



reduce bearing wear



by controlling oil film at the bearings

Oil film at the bearings keeps the metallic surfaces apart, reducing wear to a minimum. This oil film must be maintained *constantly* to be effective.

Lubrication by hit and miss methods can't be depended upon to keep bearings running smoothly. Proper lubrication requires a system which force-feeds the correct amount of oil to all bearings and carefully controls the oil flow at each individual bearing *automatically*.

This is accomplished by Bijur, the system with positive Meter-Unit control of oil flow *at the bearings*. For further details write for "The A B C of Modern Lubrication."

387

BIJUR
LUBRICATING CORPORATION
LONG ISLAND CITY 1, NEW YORK

ship to the Schrodinger equation.

A great deal of care has gone into an exposition of the differences between mechanics and a field theory and the impossibility of having a unified theoretical structure contain both. The need for an examination of the transformation properties of every physical theory has been stressed in the latter portion of the book. The number of problems has been kept small, most being of the "thinking" kind.

A Measure for Greatness

DAVID O. WOODBURY, *A.B., B.S., M.S.* 230 *pages,* 6 x 9 *in. Published by McGraw-Hill Book Co.,* 330 *W. 42nd St., New York* 18, *N. Y.* $4.

This is the biography of Edward Weston, famous electrical inventor, who migrated to this country in 1870 from England and became one of the world's most successful pioneers in the field of accurate electrical measurements through the perfection of portable instruments.

It is a simple chronological record of Weston's inventions, cast against a background of the general development of the electrical art. The gap that has existed in electrical history for a record of the origin and development of the electrical-instrument field is competently filled by this work.

This is a "from rags to riches" tale of a man who was one of the great leaders of distinguished electrical engineers of the United States and Europe. In an interesting, dramatic style, with particular emphasis placed on his personal characteristics, the story of Weston's life is traced from his first experience with electricity, through the development of his many inventions to the establishment of the Weston Electrical Instrument Company and his much-enjoyed legal entanglements. Electrical engineers will find it stimulating, and all who enjoy the accounts of colorful lives and personalities will find this story absorbing and inspiring reading.

Principles of Electroplating And Electroforming

(Electrotyping) Revised Third Edition

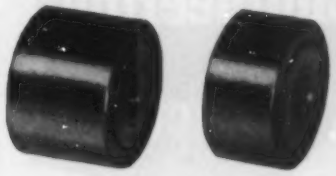
WILLIAM BLUM, *Chemist, U. S. National Bureau of Standards and* GEORGE B. HOGABOOM, *consultant.* 455*pages,* 6 x 9. *Published by the McGraw-Hill Book Co., Inc.,* 330 *West 42nd St., New York* 18, *N. Y.* $6.

This book summarizes and digests present-day knowledge of electroplating theory and practice. Designed to be of the most practical value to platers, chemists, and engineers, it

"Commercial" Ball-Bearing Data...#6 of a Series

WE WILL BE GLAD TO SEND YOU COPIES OF THE PREVIOUS ADVERTISEMENTS IN THIS SERIES.

TYPE KR AND KRS DOUBLE ROW BALL-BEARING ROLLERS WITH HARDENED TREAD



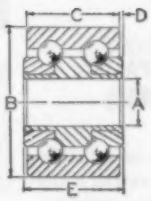
APPLICATIONS: Replace expensive precision bearings when load and speed conditions fall within limits for this type (see table below).

Replace bushings or plain sleeve bearings—eliminating costly machining and assembly time and improving efficiency.

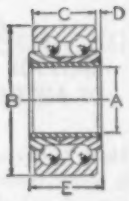
For roller applications where load cannot be handled by a single-row bearing, and lack of space prevents the use of two separate rows—in heavy stove drawers, cam rollers, etc.

FEATURES:

Anti-friction bearing performance.
Balls are highly polished, hardened steel.
Carburized, hardened, tempered parts used throughout.
All parts machined from solid bar stock.
Outer ring may be modified for specific requirements.



KR



KRS

DIMENSIONS IN INCHES—RATINGS IN POUNDS

Bearing No.	Type	A Bore	Tolerance	O. D.	B Tolerance	C O. R.	E I. R.	D Extension One or Two Sides	Balls		Load Rating at 600 RPM
									No.	Size	
CS 2885	KRS	7/16	+.003 −.001	1 5/16	+.002 −.002	1/2	1/2		34	1/8	65
CS 2226X1	KR	5/8	+.002 −.002	1 1/16	+.000 −.001	5/8	.770	2	22	3/16	95
CS 1372	KR	9/16	+.002 −.002	1 1/8	+.000 −.001	9/16	1 1/16	2	30	5/32	90
CS 2343	KR	1/2	+.002 −.002	1 1/4	+.002 −.002	1 5/16	1	2	32	5/32	100
CS 2009	KR	5/8	+.004 −.001	1 3/8	+.002 −.002	5/8	21/32	2	32	5/16	140
CS 1174	KR	3/4	+.002 −.002	1 5/8	+.002 −.002	3/4	1 1/16	2	24	1/4	190
CS 2914	KRS	1/2	+.002 −.002	2	+.000 −.005	1	1		26	5/16	320

NOTE: For load ratings at other speeds, multiply the rating at 600 rpm by the following factors:

50 rpm	100 rpm	300 rpm	800 rpm	1000 rpm
2.50	1.80	1.30	.88	.78

NEW 40-PAGE CATALOG will help you pick the right "Commercial" Ball Bearing for *your* application. Use this catalog for load-rating tables and dimension data for the complete Schatz Bearing line, as well as information on the Schatz Special Bearings Engineering Service. Many manufacturers have cut costs and increased efficiency in their plants by calling upon Schatz engineers to adapt or design a special low-cost ball bearing to fit their individual requirements. Write today for your free copy of Catalog No. 11.

SCHATZ "Commercial" BALL BEARINGS

The Schatz Manufacturing Company
6758 FAIRVIEW AVENUE, POUGHKEEPSIE, N. Y.
REPRESENTATIVES LOCATED AT
2640 Book Tower, Detroit 26, Mich. • 8 So. Michigan Ave., Chicago 3, Ill.
Chester-Twelfth Building, Cleveland 14, Ohio

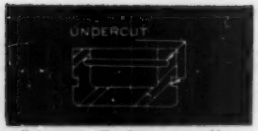
Materials Engineering Facts

HINTS FOR MOLDED PARTS OF ACE HARD RUBBER

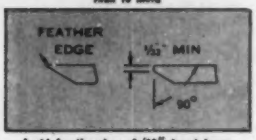
Ace Hard Rubber is a widely used thermo-setting plastic, combining outstanding chemical, physical and electrical characteristics—including high tensile strength, low moisture absorption, high dielectric strength and good machining qualities.

You can choose from Ace compounds which offer tensile strength up to 9700 psi, dielectric strength to 613 v/mil, heat resistance to 300° F. water absorption as low as 0.04—with complete (among world's largest) Ace facilities for design, molding, extruding, machining, finishing, etc.—for parts made the most economical way to your exact specifications. Also Ace plastics such as Parian (polyethylene), Saran, Ace-Tex, etc.

Always check your Ace Hard Rubber and Plastics Handbook when selecting materials. If you haven't a copy of this valuable 60-pg. manual, *write today —it's free.*

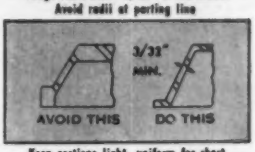


Undercuts usually cheaper to machine than to mold



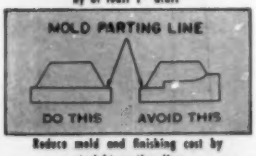
Avoid fragile edges, 1/32" is minimum

Large radii best. 1/32" is minimum. Avoid radii at parting line

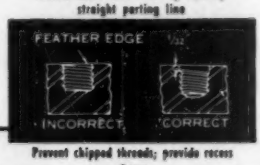


Keep sections light, uniform for short cure. 3/32" minimum

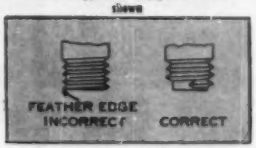
Facilitate removal of pieces and cores by at least 1° draft



Reduce mold and finishing cost by straight parting line



Prevent chipped threads; provide recess shown



Start male threads 1/32" from end

ACE AMERICAN HARD RUBBER COMPANY

HARD RUBBER and PLASTICS

11 MERCER STREET • NEW YORK 13, N. Y.

explains simply and clearly, the principles of electrochemistry and physics that underlie plating processes, and the developments in the electroplating industry. Verified formulas are given for all important plating solutions.

Analysts will find particularly valuable the arrangement in this edition of all the methods of analysis of plating solutions, now brought together in one chapter. Throughout the book, recent developments in the electro-deposition of metals are discussed thoroughly.

There is a full treatment of each of the commonly used metals, dealt with in the same sequence as in the periodic system of the elements, facilitating the direct application of specific data. There is also a full discussion of the preparation necessary for deposition on plastics, as well as a comprehensive explanation of alloy deposition.

Typical chapters include Factors that Govern the Character and Distribution of Electrodeposits; Selection, Specification and Inspection of Electrodeposits; Analysis of Solutions; Preparation for Electroplating; and, Preparation for Electroforming and Electrotyping, and for Deposition on Plastics.

Theory of Wing Sections

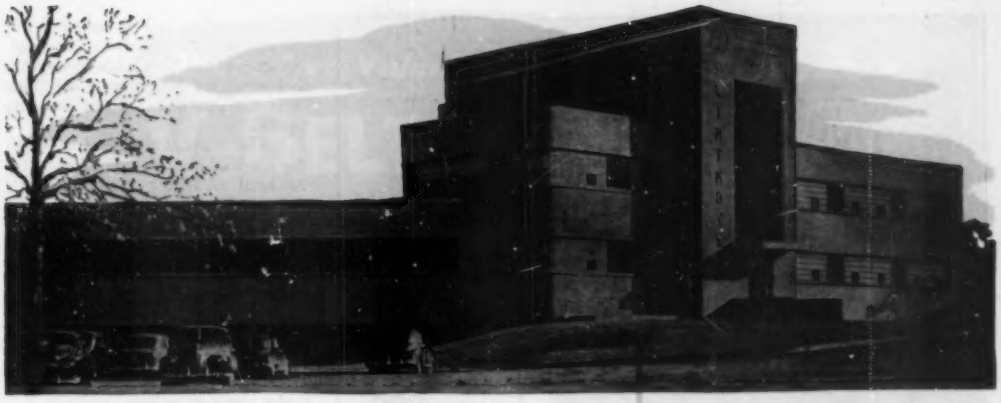
Including a Summary of Airfoil Data

IRA H. ABBOTT, *Aeronautical Consultant, National Advisory Committee for Aeronautics and* ALBERT E. VON DOENHOFF, *Head of Low-turbulence Section, Langley Aeronautical Laboratory, NACA 694 pages, 6 x 9 in. Published by McGraw-Hill Book Co., 330 W. 42nd St., New York 18, N. Y. $15.*

Intended to serve as a reference for engineers, this book will also be useful to students as a supplementary text.

An attempt has been made to present concisely the most important and useful results of research on the aerodynamics of wing sections at subcritical speeds. The theoretical and experimental results included are those found by the authors to be the most useful. Alternative theoretical approaches to the problem and many experimental data have been rigorously excluded to keep the book at a reasonable length. This exclusion of many interesting approaches to the problem prevents any claim to complete coverage of the subject but should permit easier use of the remaining material.

Consideration has been given to the needs of students and engineers with a limited background in theoretical aerodynamics and mathematics. A knowledge of differential and integral calculus and of elementary mechanics is presupposed. Care has been taken in the theoretical development to state



House of New Ideas

FOR PRODUCTS AND SALES

Flintkote employs experienced technicians... Research Specialists who spend every working day tracking down new facts on materials and methods that can improve or broaden Flintkote's wide line of products for industry.

Housed in 24 separate, efficiently equipped laboratories... in one of the most modern buildings in the country... these technicians set the pace for Flintkote plants from coast to coast. This assures better products and better results consistent with lowest possible costs ... for you.

These researchers understand what makes business "tick," too. And they accept new product requirements as a recurring challenge. Also, the quality of our materials that have been in use for decades is carefully checked for today's applications.

So, if you are a user, or a potential user of Flintkote Industrial Products for construction, manufacturing or converting, remember that these trained specialists are at your service, to help find the solution to your problems. Full scale testing and pilot production methods are available under one roof. And, they'll follow through in your own plant if you wish.

Whether your requirements are coatings, adhesives, binders, floorings... asphalt, rubber or resin compounds... Automotive, Marine, Railroad, Construction, Building Maintenance products... see what we have now and can offer you for the future.

THE FLINTKOTE COMPANY

Industrial Products Division

30 Rockefeller Plaza, New York 20, N. Y.

Atlanta • Boston • Chicago Heights • Detroit • Los Angeles
New Orleans • Washington • Toronto • Montreal

Testing effective coverage of asphalt coatings. The metal plate with coating is grounded and a charge is placed in the metal bristles of the brush. Even the smallest rupture in the film produces a visible spark, indicating incomplete protection.

Among Flintkote's many products is a line of asphaltic spray-on sound deadeners to quiet metal vibration noises. In a specially-built sound-proof room, an electronic device measures the ability of various coatings to meet rigid specifications.

Summer and Winter climate, rain and burning heat are produced in the Research Laboratory. This Twin-Arc Weather-Ometer provides accurate control of accelerated weathering tests. Products designed for exposure must survive for many years.

This small mill is used to break down various rubber materials to the right consistency for use in new products or processes. Full size operation follows in the production of versatile fluid rubber and rubber-like adhesives, coatings and the like.

FLINTKOTE

Products for Industry

Thinking of Stainless?
Think of ALLMETAL
for the finest in
STAINLESS STEEL FASTENERS
MADE RIGHT —
By specialists in stainless steel since 1929.
PRICED RIGHT —
Because ALLMETAL uses modern equipment—including cold-heading machines—devoted solely to stainless.
RIGHT COMBINATION
For solving fastening problems quickly, economically.
Allmetal has the fasteners you want. Stock items, including Government and "AN" specs, shipped immediately. Prompt delivery on various types of Phillips Recessed Head screws and specials. Switch to Allmetal Stainless Fasteners when you switch to Stainless!
Use our "Rush Order" direct wire service — Send telegrams to "Allmetal Screw Products — WUX — New York." — that's all —
WRITE FOR CATALOG 49F
MANUFACTURERS SINCE 1929
ALLMETAL
Screw Products Co., Inc.
33 GREENE STREET, NEW YORK 13, N. Y.

the assumptions and to review briefly the elementary principles involved. An attempt has been made to keep the mathematics as simple as is consistent with the difficulties of the problems treated.

The material presented is largely the result of research conducted by the National Advisory Committee for Aeronautics over the last several years. Some of the chapter headings are: The Significance of Wing-Section Characteristics; Simple Two-Dimensional Flows; Theory of Wing Sections of Finite Thickness; The Effects of Viscosity; and Effects of Compressibility at Subsonic Speeds.

The book has a complete list of references, a good set of appendices, and a complete index.

Elements of Aerodynamics Of Supersonic Flows

ANTONIO FERRI, *Ph.D., Chief of the Gas Dynamics Section at Langley Field, Va. 434 pages, 6 x 9 in. Published by MacMillan Co. 60 Fifth Ave., New York, N. Y.* $10.

Starting with the two basic hypotheses of classical aerodynamics (*a*: Air is a perfect fluid, and *b*: Air is an incompressible fluid) this book covers its subject from the practical engineering point of view.

The author is one of the foremost authorities on gas dynamics and compressibiliy. He has previously been Head of the Aerodynamics Department in the bureau directing aeronautical research for the Italian government and Associate Professor of Aerodynamics at the Graduate School of Engineering in Rome. He has also been in charge for a number of years of the supersonic wind tunnel at Guidonia, Italy. He holds doctorates in industrial electrical engineering from the University of Rome and in aeronautical engineering from the Graduate School of Aeronautics, Rome.

For such a complex subject the theory is explained as simply and clearly as possible. Many examples are included to illustrate the theory. The physical analysis of phenomena is emphasized, the correlation between theory and physical phenomena is constantly shown and the importance of the simplifications assumed in theory is clearly brought out.

There is important new material on the interaction and reflection of shock and expansion waves and on the measurement of the physical quantities of a supersonic flow. There is also new material on such topics as two-dimensional effusors, supersonic diffusors, and the drag and lift of supersonic wings that will be of great value both to design engineers and to those work-

These Two Valuable "Tools" of

V-BELT DRIVE

Design and Application

. . . are **Yours** for the **Asking!**

The Gates "GUIDE for SELECTING or DESIGNING V-BELT DRIVES" is widely recognized as the most *comprehensive* and *complete* book of its kind—and also the *easiest to use*. It enables you to find all the possible combinations of stock drives for your machine with the *least amount of calculation*—and almost *automatically* gives you the drive of *lowest price* that will be adequate for the job.

Saves You Time, Work and MONEY

The GUIDE tells all about "Design Horsepower" and Speed Ratios —and by merely *scanning* a page of GUIDE designs which use the *stock pulleys* that meet your needs, you can quickly determine the center distances that will fit your equipment layout while, at the same time, enabling you to use *standard belts!*

You Can Design ANY Drive

The Gates GUIDE tells *when* you can use a *V-Flat* drive—and gives you a simple way to choose a practical V-Flat design using *stock* driver sheave with whatever flat pulley you may already have on hand.

As a matter of fact, by using the Gates GUIDE you can design—with a *minimum of calculation*—*any kind* of V-Belt drive for every kind of operation—including quarter-turn drives and Dubl-V drives.

Written By GATES Engineers

The GUIDE is compiled and written by Gates Engineers. It embodies their specialized knowledge gained through operating the largest V-Belt testing laboratories in the world! Here, an average of *32,000 hours* of testing *per week* are run on V-Belts alone! No wonder the Gates "GUIDE for SELECTING or DESIGNING V-BELT DRIVES" is regarded by Engineers as the *authority* on V-Belt Drive design.

Also, A Monthly Report of All That's *New* and *Progressive*

The Gates "INDUSTRIAL NEWS," published monthly, gives interesting "case histories" of V-Belt drive installations designed and used by practical operating men and engineers. These case histories are selected from thousands of applications. Among other things they show — what can be accomplished with V-Belts — how to install various drives — unique applications — unique uses — examples of savings — and other valuable "how-to-do" ideas.

Whether you are a practical operating man or a design engineer, you can save much time, hard work and money by having these useful Gates publications. Just ask for them — using the coupon below. They will be sent to you without cost or obligation of any kind!

Gates VULCO ROPE DRIVES
IN ALL INDUSTRIAL CENTERS

Eng. 501

THE GATES RUBBER COMPANY
World's Largest Makers of V-Belts
DENVER, U.S.A.

The Gates Rubber Company
948 So. Broadway, Denver 17, Colorado

I would like you to send me without cost or obligation—

☐ The Gates "GUIDE for SELECTING or DESIGNING V-BELT DRIVES."

☐ Gates "INDUSTRIAL NEWS," published monthly.

Name_____

Position Held_____

Name of Firm_____

City_____ State_____

S.S. White

FLEXIBLE SHAFTS SIMPLIFY DESIGN

WHEN YOU WANT TO PUT A CONTROL IN A HANDY POSITION

This instrument (shown in part with cover removed) is an excellent example of how a short length of S.S.White flexible shafting can be used to control an inaccessible part from a convenient outside point.

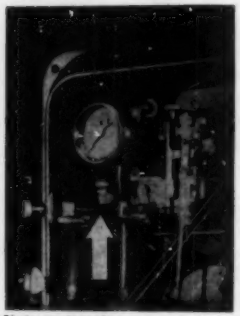


Photo courtesy of C. J. Tagliabue Mfg. Co., Bklyn, N. Y.

This is just one of hundreds of design problems that have been solved in a simple, low-cost way with S.S.White remote control and power drive flexible shafts. It will pay every designer to be familiar with these versatile, adaptable mechanical elements. For information,

GET THESE FLEXIBLE SHAFT FACTS

S.S.White MAKES IT RIGHT

BULLETIN 4501 has details on how to select and apply flexible shafting. Write for a free copy.

S.S.WHITE INDUSTRIAL DIVISION

THE J. S. WHITE DENTAL MFG. CO. DEPT. D 10 EAST 40th ST., NEW YORK 16, N. Y.

FLEXIBLE SHAFTS AND ACCESSORIES
MOLDED PLASTICS PRODUCTS—MOLDED RESISTORS

One of America's AAAA Industrial Enterprises

ing on the theoretical aspects of high-speed flow.

The whole book has been very carefully worked over, not only by the author but also by his fellow workers in the research laboratory at Langley Field in order to insure the greatest possible clarity and accuracy. It should be of great interest to aeronautical engineers and research personnel and also to others working on high speed projectiles and allied problems.

Plastic Products And Processes

U. S. Department of Commerce. 72 pages, 6 x 9 in. Published by the Superintendent of Documents, U. S. Government Printing Office, Washington, 25, D. C. Twenty-five cents.

Published in an attempt to encourage industries to adopt new product developments, this pamphlet is the third in a series of such reports. It deals exclusively with plastic products and processes. Items listed are taken from the "Register of Patents Available for Licensing or Sale". The bulletin covers products in twenty-one different fields including automobile accessories, display devices, drafting, electrical, household, medical and surgical, office devices and supplies, and toilet articles.

Elements of Thermodynamics And Heat Transfer

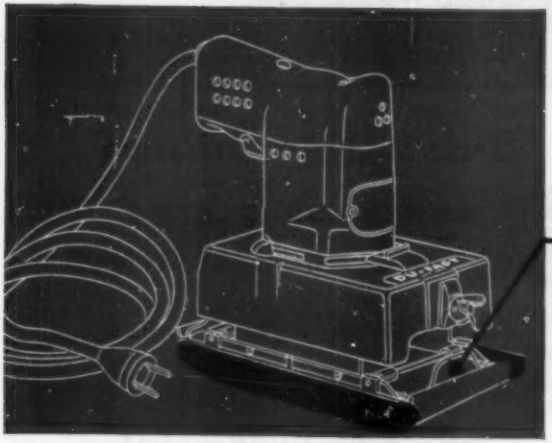
EDWARD F. OBERT, *Associate Professor of Mechanical Engineering, Northwestern Technological Institute, Northwestern University. First Edition. 375 pages, 6 x 9 in. Published by McGraw-Hill Book Co., Inc., 330 W. 42 St., New York, N. Y. $4.50.*

This text is designed for either a one- or two-semester course and is based on a condensation of the author's well-known book "Thermodynamics." The author has tried to make this presentation easy to understand without sacrificing scientific accuracy. He believes that most students do not understand thermodynamics because of confusion engendered by the number of concepts and equations that are usually presented in the first few pages of the textbook. Therefore, this text takes the position of emphasizing first the definitions of the subject, and then forming the foundation of the First Law, then the Second Law of thermodynamics upon this understanding. The book appears to be well arranged and there are numerous problems, illustrations and examples that are worked out in the text to clarify tricky problems in thermodynamic computation.

to an imaginative product designer . . .

Spongex® resilience

yielded this idea



to become

this product feature

Du-Fast sander and polisher attachment for home utility ¼" electric drill. Attachment only by Du-Fast, Inc., N. Y.

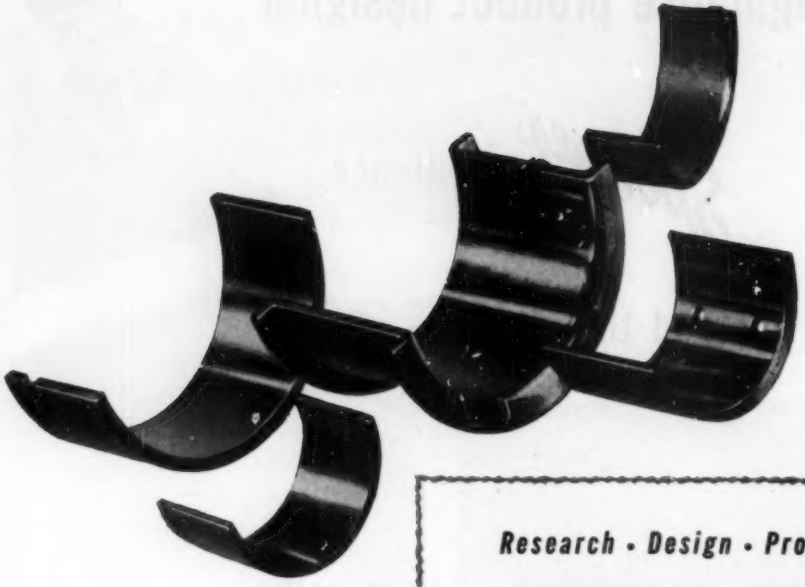
• Cellular rubber does not become a "product" until you make it one in *your* application of its known qualities as insulation against shock, vibration, sound and air and temperature transmission.

Du-Fast, Inc., wanted a sander/polisher block sufficiently resilient for conformation to curved and irregular surfaces, yet firm enough for efficient sanding and polishing. Du-Fast got the resiliency they wanted in the illustrated *Spongex* form compounded for the desired density and compression range and molded to the specifications of the unit it serves.

In every industry there exists problems that *Spongex* cellular rubber may solve. Think about it. If your thoughts are on vibration, insulation, cushioning, gasketing, sealing or sound damping, we can be your greatest help.

THE SPONGE RUBBER PRODUCTS COMPANY

302 Derby Place, Shelton, Conn.



Research • Design • Production

FOR YOUR SLEEVE BEARING REQUIREMENTS

Complete Range of Alloys

Complete Range of Sizes

PLUS *Quality Control!*

When you specify sleeve bearings, you get the advantage of a *complete* service at Federal-Mogul, in research, engineering and production, plus 50 years of specialized sleeve bearing experience. Each of our seven manufacturing plants specializes in production within a specific range of alloys and sizes, from tiny bushings to giant bearings up to 27½" diameter. In each plant our Quality Control group carries research and engineering quality standards into every phase of manufacture, from checking the quality of raw materials through to your finished bearing. A typical bearing, whether it is one of an order for 500 or for 50,000—will receive as many as 108 measurement checks, analysis, temperature and special tests and visual examinations before it is released for delivery. That's how fine performance is built into every Federal-Mogul *silent* sleeve bearing you receive. Whatever your requirements, *without obligation*, consult our research or engineering service.

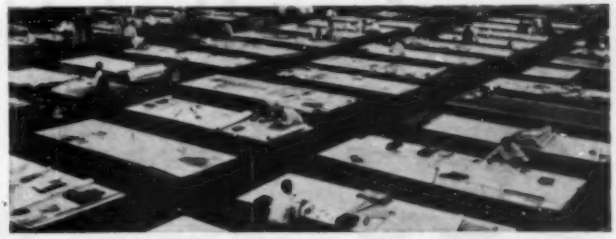
FEDERAL-MOGUL CORPORATION, 11043 SHOEMAKER, DETROIT 13, MICH.

FEDERAL Mogul *Silent* SLEEVE BEARINGS

Over fifty years of continuous bearing experience

A $75,000 per year saving in the making . . .

Streaming off this continuous processing machine at the Ford Motor Company . . . are Kodagraph Autopositive prints—positive photographic intermediates of original drawings. *The answer to a $75,000 per year redrafting headache!*



Before . . . Ford's valuable original drawings had a short life . . . had to do double duty in the drafting room and in heavy print production. In the latter operation, they were exposed to machine wear and tear, constant handling. Soon they lost their detail . . . produced illegible blueprints . . . which meant that new drawings had to be ordered from the drafting room.

Now . . . Ford's originals are filed away in the drafting room after Kodagraph Autopositive intermediates are made—available for reference and revisions only! All blueprints are produced from the "Autopositives," whose photographic black lines will not smudge or lose opacity . . . assuring highly legible prints even after hundreds of "run throughs." As a result of this simple change in routine, *redrafting costs are reduced by an estimated $75,000 per year . . . while the output of creative drafting is increased.* And print production is simplified, too . . . for Kodagraph Autopositives are not only longer-lasting . . . but can be printed at uniform, practical machine speeds.

Kodagraph Autopositive Paper

"The Big New Plus" in engineering drawing reproduction

You, too, can cut your drafting costs, get improved legibility, and simplify print production . . . by reproducing your drawings on this new, low-cost photographic intermediate paper.

You can turn out "Autopositives" quickly, economically . . . with your present print-making equipment and standard photographic processing. Or else you can order them from your local blueprinter. *It will pay you to get all the facts soon!*

MAIL COUPON FOR FREE BOOKLET

EASTMAN KODAK COMPANY
Industrial Photographic Division
Rochester 4, N. Y.

GENTLEMEN: Please send me a copy of your illustrated booklet giving all the facts on Kodagraph Autopositive Paper.

NAME_____ POSITION_____
(please print)

COMPANY_____ STREET_____

CITY_____ STATE_____

15

Kodak
TRADE-MARK

How Fafnir helps manufacturers

increase the "abuse capacity"

of portable electric tools

Out where men are men and no refreshing coolant flows, portable electric tools show the stuff they're made of. And the job they do miles from a maintenance staff, down the tracks, out on the farm, on the building site and down in the earth proves that manufacturers put plenty of "stuff" in electric tools . . . sturdily built motors, tempered steel gears and shafts, shock-resisting housings and the best ball bearings to transmit the full power of the motor to the spindle. The fact that so many leading manufacturers of electric tools use Fafnir Ball Bearings proves how well Fafnir has worked with these manufacturers in solving their special problems.

Protection of ball bearings from contaminants has been a major Fafnir project. Some of the types most commonly used in electric tools are the felt seal, the Mechani-Seal and the Plya-Seal.

Whatever your specifications for ball bearings, Fafnir can meet them more precisely, simply because Fafnir's experience is not limited to just one or two industries but is industry-wide. The Fafnir Bearing Co., New Britain, Conn.

Fafnir Felt-Seal Ball Bearing has a cartridge type seal, consisting of two metal plates enclosing a felt washer.

Fafnir Mechani-Seal Ball Bearing has a labyrinth seal, to retain grease and lock out dirt. Outer member acts as slinger.

Fafnir Plya-Seal Ball Bearing uses a flexible synthetic washer held in place by stainless steel split retaining ring.

FAFNIR
BALL BEARINGS

MOST COMPLETE LINE IN AMERICA

NEW CATALOGS AND BULLETINS

A Reader Service To Help Keep Your Library Up-to-Date

(1) **WIRE CLOTH**—Ludlow-Saylor Wire Co., 634 S. Newstead Ave., St. Louis 10, Mo. Catalog 90, 80 pp. Pictures and tabulated data described a complete line of industrial wire cloth and woven wire screens made in a variety of grades and weaves, and of almost any commercial metal or alloy.

(2) **SELF-LOCKING NUTS**—The Palnut Co., 61 Cordier St., Irvington 11, N. J. Bulletin, 4 pp. Schematic drawings and photos show principle of operation and application of the Palnut washer type, self-locking nut. Nuts are available for thread sizes 8-32 through ⅝-24. Either power or hand assembly methods may be used for installation.

(3) **CENTRIFUGAL PUMPS** — Allis-Chalmers, Milwaukee 1, Wisc. Two bulletins, total 32 pp. First bulletin is a "Handy Guide to Selection of Centrifugal Pumps." Complete tables and outline drawings give full information needed for the selection of single and 2-stage pumps, both single and double suction. Second bulletin called "Handbook for Care of Centrifugal Pumps" contains many cartoons to show exactly how a centrifugal pump is made, what the danger zones are and full maintenance procedures.

(4) **MOLDING COMPOUNDS** — Libbey-Owens-Ford Glass Co., Plaskon Div., 2113-Sylvan Ave., Toledo 6, Ohio. Bulletin, 12 pp. Four-color bulletin gives the history, properties, applications, and moldability of Plaskon urea and melamine formaldehyde molding compounds.

(5) **PRE-FINISHED METALS** — American Nickeloid Co., Peru, Ill. Bulletin, 16 pp. Pictures and complete tabulated data describe Nickeloid metals, which are brass, zinc, copper, steel, or aluminum base, pre-finished metals that can be stamped or formed without marring surface finish. Suggested fabricating techniques are given.

(6) **VALVE PACKING MATERIALS** — Crane Packing Co., 1800 Cuyler Ave., Chicago 13, Ill., 2 bulletins, 12 pp, total. Describes a line of chemically inert valve packing materials made in a number of styles for use at various temperatures with corrosive liquids. Other bulletin presents a coil form and spiral form packing.

(7) **VARIABLE SPEED PULLEY** — Equipment Engineering Co., 2853 Columbus St., Minneapolis, Minn. Bulletin, 4 pp. Shows a pulley that uses spring loaded pulley face to give variable speed transmission. Exploded view photos show construction features.

(8) **HIGH STRENGTH STEELS**—Jones & Laughlin Steel Corp., Pittsburgh 30, Pa. Bulletin, 32 pp. Describes "Otiscoloy," a low alloy, high strength steel widely used in the transportation industry. Physical properties and other technical data are given. Pictures show various applications.

(9) **PHOSPHOR BRONZE** — Phosphor Bronze Corp., 2300 Washington Ave., Philadelphia 46, Pa. Data book, 32 pp. Gives full engineering data on phosphor bronze strip and sheet, wire, rod, rope, castings, bushings, and ingots. Also has many useful tables and formulas.

(10) **FIBERGLAS THERMAL INSULATION**—Owens-Corning Fiberglas Corp., Toledo 1, Ohio. Booklet, 16 pp. Describes all forms of Fiberglas thermal insulations for both industrial and building applications. Data on thermal conductivity and sound absorption properties are included. Many application photos are given.

(11) **VENTURI-BALL VALVES** — Paul Valve Corp., 282 Third Ave., New York 17, N. Y. Bulletin 102, 16 pp. Covers the principle of operation and gives engineering data on the complete line of Venturi-Ball Valves, including "whistle," bar stock, cast steel and stainless steel and forged valves. Types include standard handwheel, quick-opening, lever, diagram, piston and cylinder, solenoid, and emergency-trip casualty valves.

(12) **TACHOMETERS** — Reeves Pulley Co., 5006 Euclid Ave., Cleveland 3, Ohio. Bulletin, 8 pp. Presents mechanical and electrical type tachometers for use with Reeves variable speed drives. The mechanical type is accurate to ± 4 percent; the electrical type to ± 1 percent. Full information is given concerning installation, maintenance, mounting directions and calibration.

(13) **STRAIN GAGES**—The Baldwin Locomotive Works, Philadelphia 42, Pa. Bulletin 279-A, 12 pp. Tells how to select and use SR-4 bonded resistance wire strain gages in stress analysis. It explains the fundamentals of strain gage circuits and instruments.

(14) **SEALED BALL BEARINGS**—Nice Ball Bearing Co., Nicetown, Philadelphia, Pa. Bulletin, 4 pp. Announces a line of ball bearings with an oil resistant synthetic rubber coated fabric seal which retains lubricant and excludes foreign material. Sizes range from 3/16 to 1 5/16, inside dia, in both ground and unground styles.

(15) **AIR CIRCUIT BREAKERS**—Roller-Smith, Bethlehem, Pa. Catalog 2150, 24 pp. Describes the RS air circuit breaker, which is for protection of feeder circuits and for use as a main circuit breaker on medium capacity systems. They are available in both 15,000 and 25,000 rms amp interrupting capacities, with potential ratings of 250 v, dc, and 600 v, ac for each type.

(16) **SMALL TRANSFORMERS** — Audio Development Co., 2833 Thirteenth Ave., South, Minneapolis 7, Minn. Catalog 49A, 16 pp. Presents a line of transformers to be used by the electronic audio industry. Also gives technical data on allied products, such as chokes, filters, jacks, plugs, reactors, etc.

(17) **PRECISION BRAKE ACCESSORIES**—O'Neil-Irwin Mfg. Co., Lake City, Minn. Bulletin, 4 pp. Presents a new accessory called "precision box fingers" which converts any "Di-Acro" brake to a precision box and pan brake.

(18) **DATA SHEETS**—Letax, Philadelphia 7, Pa. Catalog, 48 pp. Gives prices, number of pages, and subject matter of a great number of technical data sheets and standard forms. Data sheets cover most of the standard engineering subjects.

HOW TO ORDER — Two post cards are printed here. On each is room for you to request four pieces of literature. If you are requesting four pieces or less, please use only the bottom card. For five to eight pieces use both cards.

Write in circle number of item describing one catalog wanted →

Name.....

Company.....

Address.....

..... Title.....

PRODUCT ENGINEERING, New York. 2-50
Not Good after April 1, 1950

Write in circle number of item describing one catalog wanted →

Name.....

Company.....

Address.....

..... Title.....

PRODUCT ENGINEERING, New York. 2-50
Not Good after April 1, 1950

Write in circle number of item describing one catalog wanted →

Name.....

Company.....

Address.....

..... Title.....

PRODUCT ENGINEERING, New York. 2-50
Not Good after April 1, 1950

Write in circle number of item describing one catalog wanted →

Name.....

Company.....

Address.....

..... Title.....

PRODUCT ENGINEERING, New York. 2-50
Not Good after April 1, 1950

PLACE 3¢ STAMP HERE

PRODUCT ENGINEERING

330 West 42nd St.

New York 18, N. Y.

(19) INSTRUMENT VALVES — Edward Valves, Inc., East Chicago, Ind. Bulletin 491, 4 pp. Illustrates the 952 series forged steel valve, which is for use with orifice meters, regulators, gage lines, corrosive lines, etc. Valves come in both carbon steel and chromium steel types for up to 6,000 lb working pressures.

(20) SCREWS AND LOCK WASHERS—Pheoll Mfg. Co., 5700 Roosevelt Rd., Chicago, Ill. Catalog 50 A, 26 pp. Gives sizes and specifications of slotted head, Phillips recessed head and hexagon head screws assembled with external and internal tooth lockwashers or spring lockwashers. Also gives price list.

(21) SILENT CHAIN DRIVES—Whitney Chain & Mfg. Co., Hartford 2, Conn. Catalog SCS-49, 32 pp. Gives full engineering specifications and applications of silent chain, sprockets, bushings, and stock drives. Also comments on chain drive design, length calculations, and drive selection.

(22) SEAMLESS COPPER TUBING—Penn Brass & Copper Co., Erie, Pa. Bulletin, 6 pp. Gives method of manufacture and uses of seamless tubing. Uses include automotive, refrigeration, and bottle gas applications, where tubing must be especially clean.

(23) GROOVED WHEEL CASTERS—The Bassick Co., Bridgeport, Conn. Bulletin, 8 pp. Presents a line of "V" grooved wheels for operation on angle iron track. Bulletin also gives instructions on laying track for corner turns, turn-and-crossover, and switch installation. Sizes and photos of the casters are shown.

(24) ABRASIVE-RESISTANT RUBBER —B. F. Goodrich Co., Akron, Ohio. Bulletin 9010, 4 pp. Describes "Armorite", which is used as a protective rubber lining to handle abrasive materials. Thickness and types of "Armorite" are recommended for various applications.

(25) METAL CLEANERS — Enthrone, Inc., Dept. PE, 442 Elm St., New Haven 2, Conn. Data sheets, 5 pp., total. Gives uses, operating instructions, controls, and other pertinent data on 5 types of cleaners for zinc, aluminum, steel and brass.

(26) GAGES AND THERMOMETERS—Jas. P. Marsh Corp., Skokie, Ill. Catalog 76-M, 120 pp. Catalog shows a complete line of gages in types ranging from altitude, ammonia and freon gages to hydraulic, vacuum, and test gages. Also shows a complete line of thermometers and accessories.

(27) ROTARY PUMPS—De Laval Steam Turbine Co., Trenton 2, N. J. Bulletin LG, 4 pp. Shows cut-away drawings of the six different types of De Laval-IMO rotary pumps, along with a brief description of each. The IMO pump is designed to handle residual and distillate fuel oils, crude oils, all grades of lubricating oils, hydraulic oils and viscous fluids. Capacities range from 0.5 to 1000 gpm for pressures to 500 psi and capacities to 150 gpm for pressures to 1500 psi.

(28) LOW LEVEL CONDENSERS — Schutte and Koerting Co., 13th and Thompson Sts., Philadelphia 23, Pa. Bulletin 5A, 12 pp. Cut-away views and drawings show construction and application of low-level, multi-jet condensers. All pertinent data given.

(29) EXPANDED METAL — United States Gypsum Co., Bulletin, 12 pp. Photos show how expanded metal is made and used. Sizes and other specifications are given. Application photos show typical uses. The necessary technical data are listed.

(30) NON-DESTRUCTIVE TESTING — Sperry Products, Inc., Danbury, Conn. Bulletin 50-105, 4 pp. Describes the type "UR" ultrasonic reflectoscope, an instrument for the non-destructive testing of metals and other materials. Pictures and text give principles of operation and applications.

(31) FABRICATED MICA—Mica Fabricators Association, 430 Lexington Ave., New York 17, N. Y. Booklet 16 pp. The booklet gives pertinent facts on natural sheet and block mica with emphasis on the characteristics required for its use in the electrical industry. It is designed to help manufacturers of electrical, radio and electronic equipment to select the best and most economical grade and quality of mica for any given application.

(32) RESIN GLUES—Libbey-Owens-Ford Glass Co., Plaskon Division, Toledo 6, Ohio. Booklet 96 pp. This manual will assist manufacturers of plywood, furniture and allied industries in the proper use of Plaskon hot and cold setting resin glues. It gives techniques of gluing, a glue selector chart and has a complete appendix giving literature references, methods of tests and useful formulae.

(33) ALUMINUM ALLOYS—Revere Copper and Brass, Inc., 230 Park Ave., New York 17, N. Y. Bulletin, 4pp. Tabulates full physical properties of 10 standard aluminum alloys. Also gives physical properties of aluminum tubing made in 5 different alloys.

(34) TESTING METHODS AND FACILITIES — Owens-Corning Fiberglas Corp., Toledo 1, Ohio. Bulletin, 36 pp. Describes methods and facilities used by the company to provide accurate data on Fiberglas products. Many photographs provide interest.

(35) TEMPERATURE CONTROLS—H-B Instrument Co., 2633 Treaton Ave., Phila., Pa., Bulletin 14, 16 pp. A guide for the selection of equipment used in signaling and controlling temperature in both laboratory and plant installations. Equipment includes panel mounted or enclosed normally-open and normally-closed mercury relays, single and multi-contact thermoregulators, automatic overtemperature cutouts, complimentary relays and slector switches, mercury thermostats and temperature controls.

(36) ELECTROPLATING EQUIPMENT —Warner Electric Co., 1512 W. Jarvis Ave., Chicago 26, Ill. Catalog D. 44 pp. A complete catalog of small equipment and supplies for electroplating. Will be useful for experimental laboratories and model making as well as home-craft work.

(37) HYDRAULIC PUMPS AND CYLINDERS—The Commercial Shearing & Stamping Co., Youngstown, Ohio. Bulletin, 6pp. Gives design details, specifications, and applications of hand operated hydraulic pumps and single acting cylinders. Cylinders and pump operate at pressures up to 5,000 psi in any position.

(38) SMALL MAGNETIC STARTER—The Arrow Hart & Hegeman Electric Co., Hartford, Conn. Bulletin, 12pp. Presents the type "RA" magnetic starter, which is about half the size of conventional starters of the same ratings. Horsepower ratings range from 1 to 7½. Three types of starters are shown. Wiring diagrams and specifications are given.

(39) BRONZE BEARINGS AND CASTINGS—American Brake Shoe Co., National Bearing Div., St. Louis 10, Mo. Bulletin 25 pp. The bulletin shows the facilities of the National Bearing Div. and describes the bronze and copper bearings, castings, alloys, bar stock and babbitt metals that they manufacture. Pictures and tabulated information describe each product and give physical properties and sizes available.

HOW TO ORDER — Two post cards are printed here. On each is room for you to request four pieces of literature. If you are requesting four pieces or less, please use only the bottom card. For five to eight pieces use both cards.

PLACE 3¢ STAMP HERE

PRODUCT ENGINEERING

330 West 42nd St.

New York 18, N.Y.

Write in circle number of item describing one catalog wanted →

Name.....

Company.....

Address.....

.....Title.....

PRODUCT ENGINEERING, New York. 2-50

Not Good after April 1, 1950

Write in circle number of item describing one catalog wanted →

Name.....

Company.....

Address.....

.....Title.....

PRODUCT ENGINEERING, New York. 2-50

Not Good after April 1, 1950

Write in circle number of item describing one catalog wanted →

Name.....

Company.....

Address.....

.....Title.....

PRODUCT ENGINEERING, New York. 2-50

Not Good after April 1, 1950

Write in circle number of item describing one catalog wanted →

Name.....

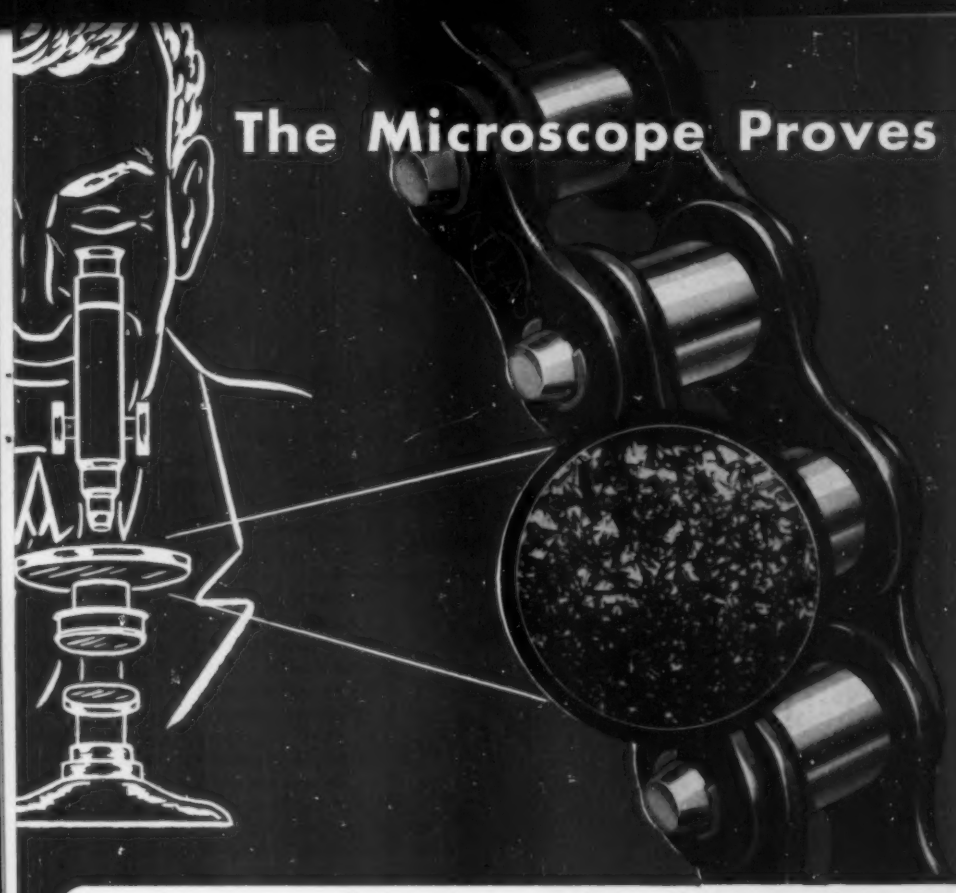
Company.....

Address.....

.....Title.....

PRODUCT ENGINEERING, New York. 2-50

Not Good after April 1, 1950



ATLAS CHAIN HAS LONGER LIFE!

Run roller chains through your hands and they all look alike. Put Atlas Chain under a microscope and you'll see the difference!

A metallographic microscope will reveal that all of the parts of Atlas Roller Chain are made of carefully selected steels . . . and scientifically heat treated for longer wear. Parts subject to excessive wear are treated to be tough by the special "Nicarb" Process. The effects of "Nicarbing" are revealed by the surface which combines the advantages of both carburizing and nitriding.

An outer rim of nitride needles knits together a base of carbide particles and binds them strongly to the core of steel. This nitride enriched outer surface, along with the binding qualities induced, proves by test to impart greater strength and wear resistance than conventional hardening. In addition, all parts take on an unusual resistance to corrosion and oxidation.

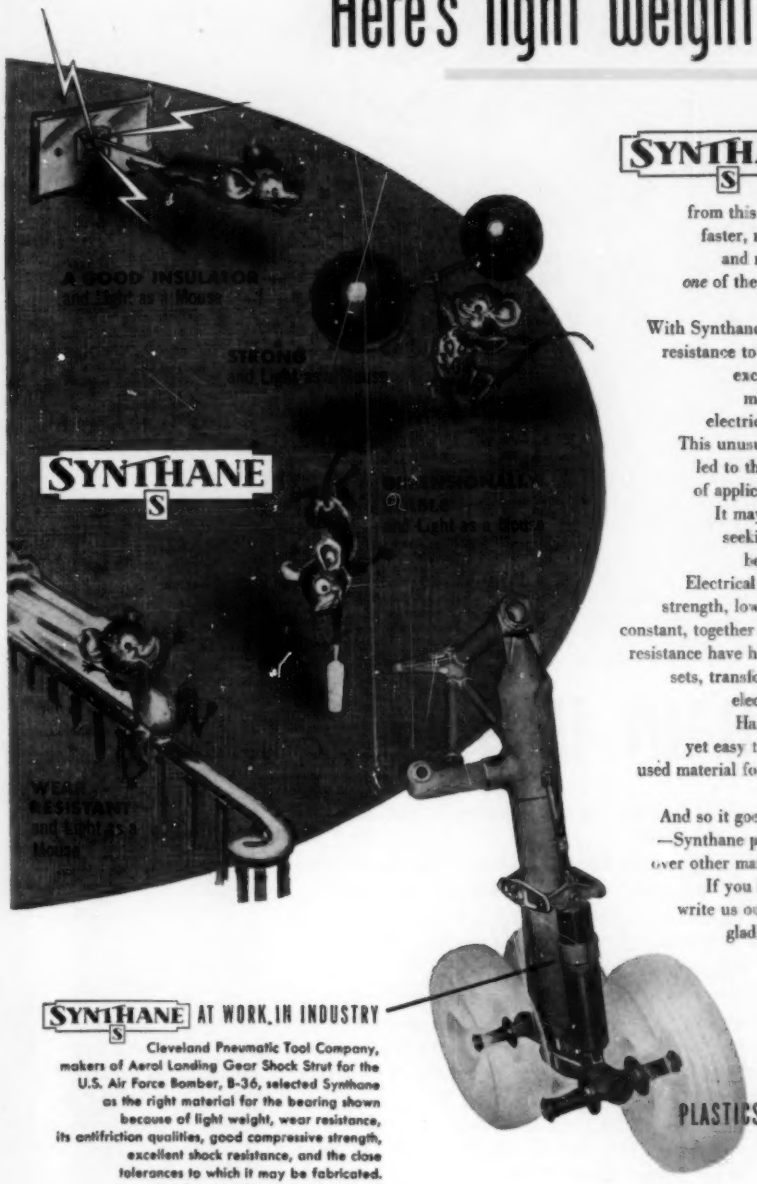
If you are interested in boosting the life of chain drives on your products or machines, take advantage of the longer life built into every link of Atlas Chain. Call in an Atlas representative for further details. Prices and specifications are available in our new catalog. Write for your free copy.

Conventional Hardening

ATLAS CHAIN & MANUFACTURING CO.

CASTOR & KENSINGTON AVENUES PHILADELPHIA 24, PENNA.

Here's light weight and much



SYNTHANE is half the weight of aluminum. Moving parts made from this type of laminated plastics start faster, require less power to start, stop and run . . . and light weight is only *one* of the Synthane properties that make it a valuable material for you.

With Synthane you get light weight, strength, resistance to wear, dimensional stability and excellent electrical insulation, plus many other desirable mechanical, electrical and chemical characteristics. This unusual *combination* of properties has led to the use of Synthane in thousands of applications in almost every industry. It may be the material you have been seeking to help make a good product better or a process less expensive.

Electrical qualities such as high dielectric strength, low power factor and low dielectric constant, together with light weight and moisture resistance have helped put Synthane in television sets, transformers and many other pieces of electrical and electronic equipment.

Hard, dense and abrasion resistant, yet easy to machine, Synthane is a widely used material for long-wearing, high-speed gears, cams and rubbing blocks.

And so it goes in application after application —Synthane pays for itself in extra advantages over other materials. It may be helpful to you. If you have a specific material problem, write us outlining the situation. We will be glad to help with material, design, or fabrication of finished parts.

Synthane Corporation,
Oaks, Pennsylvania.

SYNTHANE AT WORK IN INDUSTRY

Cleveland Pneumatic Tool Company, makers of Aerol Landing Gear Shock Strut for the U.S. Air Force Bomber, B-36, selected Synthane as the right material for the bearing shown because of light weight, wear resistance, its antifriction qualities, good compressive strength, excellent shock resistance, and the close tolerances to which it may be fabricated. Are these qualities valuable to you?

PLASTICS WHERE PLASTICS BELONG

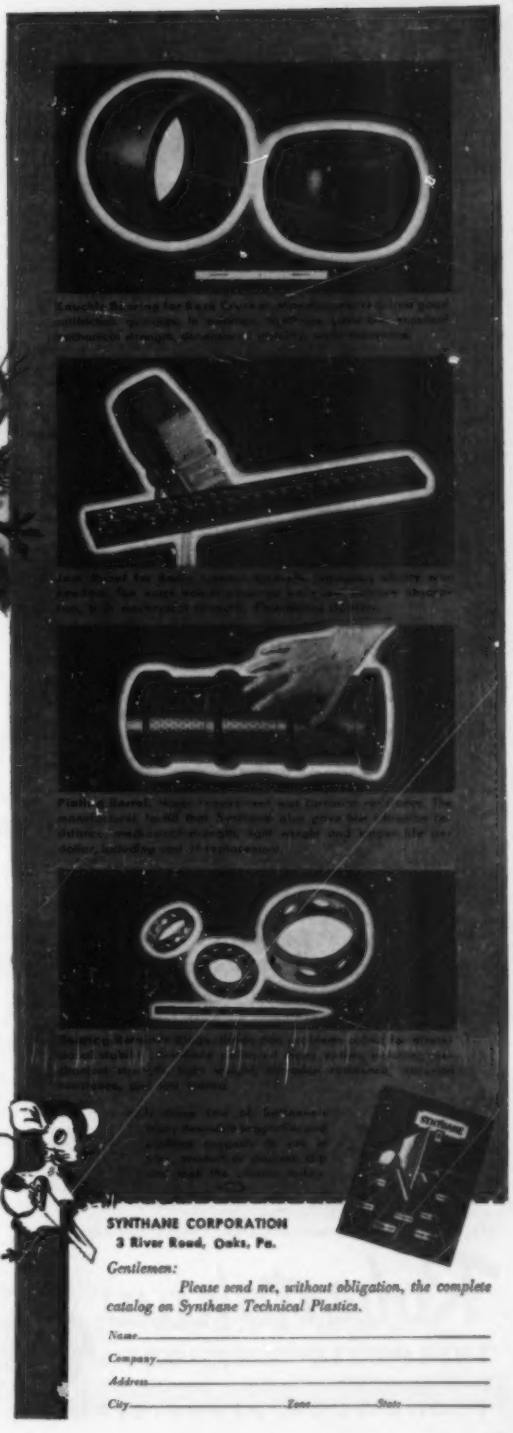
more in a material

Here

ARE YOUR ADDED VALUES

Synthane was the material selected for each of the four parts shown at the right. Each manufacturer sought one or two specific characteristics. In each application the user found that Synthane was not only a better material for the major requirement but gave him other desirable properties. This is true of almost every application, for Synthane is unusual for its *combination* of properties.

Synthane is strong, hard, light and dense. Resists abrasion, corrosion, is easily worked on standard machine tools. It is an excellent electrical insulator, has high dielectric strength, low dielectric constant and low power factor. It is a *set* plastic, dimensionally stable over a wide range of temperatures.



SYNTHANE

WHERE SYNTHANE BELONGS

SYNTHANE CORPORATION
3 River Road, Oaks, Pa.

Gentlemen:

Please send me, without obligation, the complete catalog on Synthane Technical Plastics.

*Name*_____

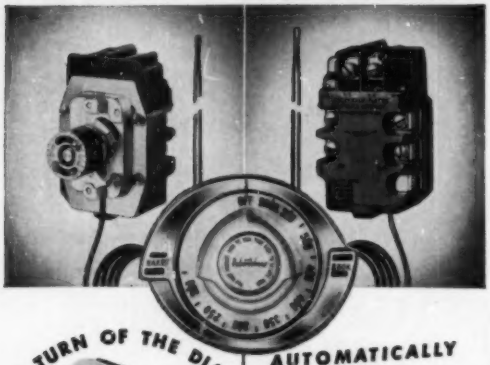
*Company*_____

*Address*_____

*City*_____ *Zone*_____ *State*_____

New Robertshaw 3 in 1 Control

FOR ELECTRIC RANGE OVENS



A TURN OF THE DIAL

AUTOMATICALLY 1

Cuts in two oven elements for quick preheating

AUTOMATICALLY 2

Cuts out top element shortly before oven reaches preheat temperature minimizing overshoot

AUTOMATICALLY 3

Cuts in lower element and maintains oven temperature on that circuit only

A new high degree of automatic control of oven temperature is made possible by the new complete line of Robertshaw Electric Thermostats. The model illustrated combines the thermostat with automatic switching mechanism in a compact, easy-to-install case. Four mounting positions are provided, together with close-up or extended bezel to fit any switch panel in range-top or counter-back position.

All operating parts have been reduced in size, and terminal screws are recessed to save space. Screws are inserted from rear, increasing accessibility and simplifying installation.

Complete line consists of three basic models. Write for complete information.

In home and industry, **EVERYTHING'S UNDER CONTROL**

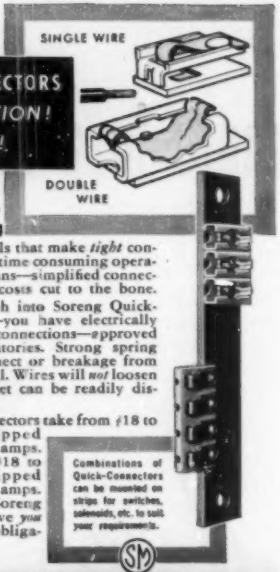
Robertshaw

THERMOSTAT DIVISION

ROBERTSHAW-FULTON CONTROLS COMPANY

YOUNGWOOD, PENNSYLVANIA

NEW QUICK-CONNECTORS SPEED PRODUCTION! CUT COSTS!


SINGLE WIRE
DOUBLE WIRE
Combinations of Quick-Connectors can be mounted on strips for switches, solenoids, etc. to suit your requirements.
SM

No Screws or Male Plugs—No Looping, Eyeletting or Splicing

At last—electrical terminals that make *tight* connections without the usual time consuming operations. Think what that means—simplified connections, faster production, costs cut to the bone.

Simply strip wires, push into Soreng Quick-Connectors, and presto—you have electrically and mechanically tight connections—approved by Underwriters' Laboratories. Strong spring pressure prevents disconnect or breakage from vibration or accidental pull. Wires will *not* loosen in shipment or service, yet can be readily disconnected if necessary.

Single wire Quick-Connectors take from #18 to #14 solid or solder-dipped stranded wire. Rated 15 amps. Double wire take from #18 to #10 solid or solder-dipped stranded wire. Rated 30 amps. Why not find out *now* how Soreng Quick-Connectors can save *your* money? Write, without obligation, to Dept. NO2.

SORENG MANUFACTURING CORPORATION

Main Plant — 9555 Eden Ave., Schiller Park, Ill. (Suburb of Chicago)

Branch Plant — 231 Stone St., Fremont, Ohio

Can't Shake Loose...

Standard's Locknuts and Lockwashers are made to stay . . . you can't shake them loose. They're easy to apply, durable, and can be used again and again. Order Standard Locknuts, Lockwashers, and Adapters for your application of ball and roller bearings . . . S.A.E. Standard, A.B.E.C. Standard, Heavy-duty and Specials.

Locknuts in sizes N-00 through AN-40 . . . Multi-prong Lockwashers in sizes W-00 through W-40 . . . Adapter sizes 7-9-11-13 for shaft sizes 1 $\frac{7}{16}$", 1 $\frac{15}{16}$", 1 $\frac{13}{16}$", 2 $\frac{7}{16}$" . . . standard shaft collars, sizes $\frac{1}{2}$", $\frac{5}{8}$", $\frac{3}{4}$", $\frac{7}{8}$" and 1". Order now from our complete stock.

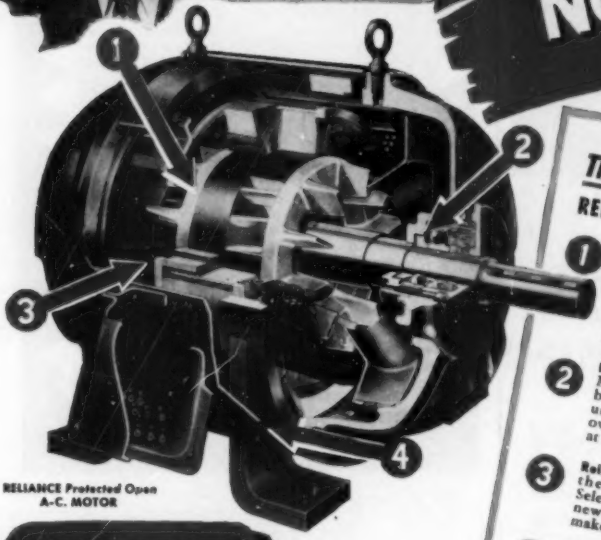
Standard

LOCKNUT & LOCKWASHER, INC.

118 W. ST. CLAIR ST., INDIANAPOLIS 4, INDIANA

WHY HASN'T SOMEBODY TOLD ME THIS BEFORE?

"...all motors are NOT ALIKE"



RELIANCE Protected Open A-C. MOTOR

These 4 Advantages Alone make RELIANCE the motor that is different!

1. **Dynamic Balancing—Precision Fits**—Every motor is dynamically balanced by skilled technicians using latest electronic-principle equipment. Machining of parts to exacting tolerances guarantees precision fits throughout. Result: a smoother-running, longer-lasting motor!
2. **No Lubrication Worries**—Precision Bearing Mounting, with double-shielded ball bearings, assures longer bearing life under all normal conditions, whether overgreased, undergreased or not greased at all. *"You can't grease 'em wrong!"*
3. **Reli-X Insulation** furnishes a new high in the protection of stator windings. Selected materials, exclusive methods and new continuous-sequence applications make this the *unfailing* insulation!
4. **Steel for Strength**—Steel construction, with electrically welded joints, combines maximum strength with minimum weight.

RELIANCE *Precision-Built* MOTORS

...are made *better* to deliver DEPENDABLE POWER—LONGER!

Reliance has a way of building motors that must be seen to be fully appreciated. Any time we can take a motor user through the modern plants where Reliance *Precision-Built* Motors are made we can be reasonably sure of another good Reliance customer. We would be delighted to have you make this visit. But if it isn't practical, call in your nearest Reliance representative and *see* the convincing facts he can show you on the precision methods that produce these truly superior motors. Now available from ¾ to 300 horsepower.

HOW TO SELECT THE RIGHT MOTOR

Here's a book which digests all the information you should have in selecting the motor that's just right for any job. New torque and current standards recently adopted by the National Electrical Manufacturers Association for A-C. motors are tabulated and explained. And these are further supplemented by more detailed performance data on Reliance *Precision-Built* Motors. Write today for this important new Motor Data Bulletin, B-2101.

Sales Representatives in Principal Cities

RELIANCE ELECTRIC AND ENGINEERING CO.

"Motor-Drive is More Than Power" • 1060 Ivanhoe Road, Cleveland 10, Ohio

An Arwood casting combines 7 parts in 1

HERE is a typical example of Arwood designing for economy. The illustration shows a stainless steel ratchet previously made from 7 parts — 1 cam, 1 ratchet, 1 stop pin, 1 hub and 3 hollow rivets on the underside.

Design results that are able to produce important savings such as this are made possible only by Arwood's years of experience in many industries.

Perhaps Arwood can make important savings for you, too, savings that will increase your output and profits in today's competitive market. Our engineers are at your service without any obligation whatever.

For more complete information about the accuracy, the lower costs and the versatility of precision casting, write for our booklet, "A Critical Survey of Investment Casting."

ARWOOD

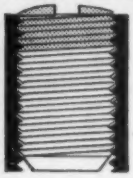
PRECISION CASTING CORP.

68 WASHINGTON STREET • BROOKLYN 1, N. Y.

SET SCREWS

Profit by Set Screw Specialization on Puzzling Set Screw Problems

Over 1200 Manufacturers, large and small, depend on Setko for Set Screws. Do you have set screw problems like these: Tough Service; "Tricky" Applications; Small Sizes; Special Materials; Rush Shipments? Then Setko can help you. Write, wire or phone today for catalog, in-stock lists, quotations.



ANOTHER EXAMPLE OF HOW SETKO SOLVES PUZZLING SET SCREW PROBLEMS

ZIP-GRIP* *Self-locking* **SET SCREWS and ADJUSTING SCREWS**

Zip-Grip is first with Triple-Locking Action: Interference Fit PLUS Tension PLUS regular Locking Acion of Set Screw on Shaft or other part. Also the first to require no supplementary devices or deformed threads. Licks vibration and locks instantly, any given place. For complete description and application data write for new Zip-Grip Data Sheet.

Set Screw & Mfg. Co. SETKO

*Pat. Pend.

153 Main St., Bartlett, Ill.

We Specialize in Solving Puzzling Set Screw Problems

SEE THE PIONEER COOLANT AND LUBRICANT PUMPS AT THE A.S.T.E. SHOW

PIONEER Pumps

HIGH EFFICIENCY • LOW POWER CONSUMPTION
GREATER VOLUME AND LESS MAINTENANCE

PIONEER PUMP & MANUFACTURING CO.

19664 JOHN R STREET • DETROIT 3, MICHIGAN

CUSTOM BUILT MACHINERY

FOR OVER 75 YEARS

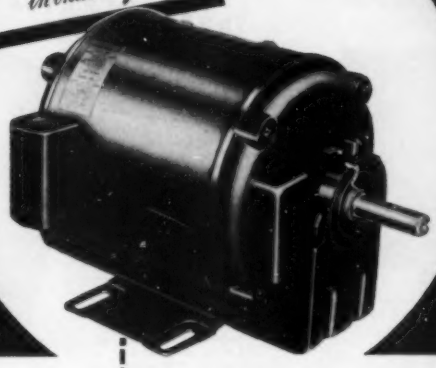
DIXIE-COWDREY *Machine Corporation*

(A subsidiary of the Dixie Cup Co.)

Write:
DIXIE-COWDREY
Fitchburg, Mass.
Telephone: Fitchburg 5200

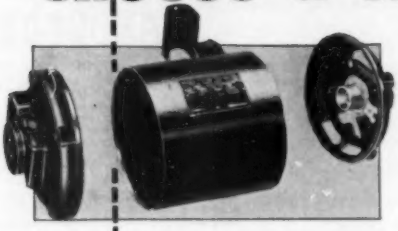
● DESIGNERS AND BUILDERS OF SPECIAL PURPOSE MACHINERY

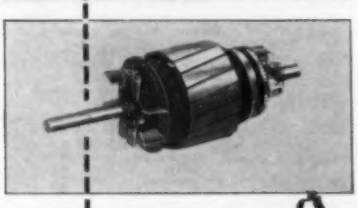
WAGNER MOTORS
...The choice of leaders in industry

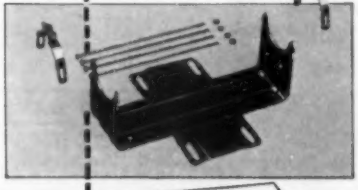


Power Your Product With Dependability

Choose a Wagner Motor







Every painstaking step in the construction of Wagner Motors reflects the sound engineering and good workmanship that have made them famous for quality and durability for almost sixty years.

Wagner Motors are available in a wide range of types and sizes for every application. They are compactly built without sacrificing strength or efficiency and are the first choice of many manufacturers because of their dependable performance.

If you need motors that will give long, trouble-free performance and build customer satisfaction—choose Wagner Motors. Bulletin MU-185 gives complete information.

* * *

Buyers of Wagner Motors get Nationwide Service! More than 450 Wagner Authorized Electrical Service Stations and Parts Distributors augmented by 25 Wagner-owned Service Branches are ready to supply on-the-spot service, factory guaranteed exchange motors, or genuine Wagner Parts. Write for Bulletin MU-24 for the complete list of names and locations.

WAGNER ELECTRIC CORPORATION
6406 Plymouth Ave., St. Louis 14, Mo., U.S.A.

Wagner Electric Corporation
EST. WE 1891

ELECTRIC MOTORS · TRANSFORMERS · INDUSTRIAL BRAKES
AUTOMOTIVE BRAKE SYSTEMS – AIR AND HYDRAULIC

BRANCHES IN 29 PRINCIPAL CITIES

MB-1

TRAILER HITCH MANUFACTURER PROFITS WITH SWITCH TO

UNITCASTINGS!

AS A UNITCASTING

- Cost Substantially Less!
- Machine Work Reduced!
- Appearance Improved!
- Accuracy Eliminates Mis-Fits!

After the mechanical success of weldment pilot models, this manufacturer found it didn't answer any of his marketing problems.

Unitcast engineers gave him the answer. Keeping quality first, Unitcastings gave him low end costs, castings with more eye appeal, additional strength, greater safety and no misfits. Results: trailer hitch sales have increased several hundred percent—proving again that your customer will "beat a path" to a better Unitcasting, one that's correctly engineered for the job.

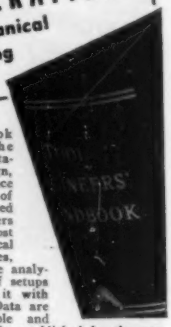
UNITCAST
Corporation
QUALITY STEEL CASTINGS

Unitcast will welcome the opportunity to provide a "cast steel" answer for your parts problems, too. Our suggestions toward design, *while your product is still on paper*, may save you many dollars in time and future revisions! Write or call today! Unitcast Corporation, Steel Casting Division, Toledo 9, Ohio. *In Canada:* Canadian-Unitcast Steel, Ltd., Sherbrooke, Quebec.

UNITCASTINGS ARE FOUNDRY ENGINEERED

JUST PUBLISHED

An outstanding reference on
PLANNING, CONTROL DESIGN, TOOLING and OPERATIONS
in the mechanical manufacturing industries



THIS handbook brings you the most modern authoritative data on the design, fabrication, maintenance and economical use of tools and machinery used in industry. It covers product design and cost estimating, the economical selection of machines, processes, and tools, the analysis and improvement of setups and operations. Use it with complete confidence. Data are based wherever possible and practicable, on standards established by the government, professional associations and leading industrial companies.

TOOL ENGINEERS HANDBOOK

American Society of Tool Engineers
Frank W. Wilson, Editor-in-Chief

Written by 144 authorities in the field, this massive reference, consisting of 115 big sections covering tool engineering from A to Z, has been checked and double checked from cover to cover to insure accuracy. Here are the complete, authoritative answers to your problems, brought to you in compact, easy-to-find form.

More than 2000 pages! Over 1500 illustrations! Hundreds of tables, charts, keyed diagrams, symbols, definitions, equations, etc.

A small selection of highlights selected at random to illustrate the scope of this Handbook:

- Describes types of machines, cutting tools, tool holders, fixtures and operations in precision production boring.
- Includes all new techniques and processes of recognized acceptance including Powder Metallurgy, Investment Casting, Plastic Joining of Materials, etc.
- Conventional tables of feeds, speeds and cuts modernized to bring them into line with latest cutting-tool materials and cutting practices.
- Treats, process-wise, such topics as Plaster Mold Casting, Superfinishing, Rotary Swaging, Sheet and strip cold roll forming, Die Hobbing, etc.
- Covers every phase of metal cutting and machinability.
- Discusses welding, gluing and mechanical joining of materials.

SEE IT 10 DAYS FREE

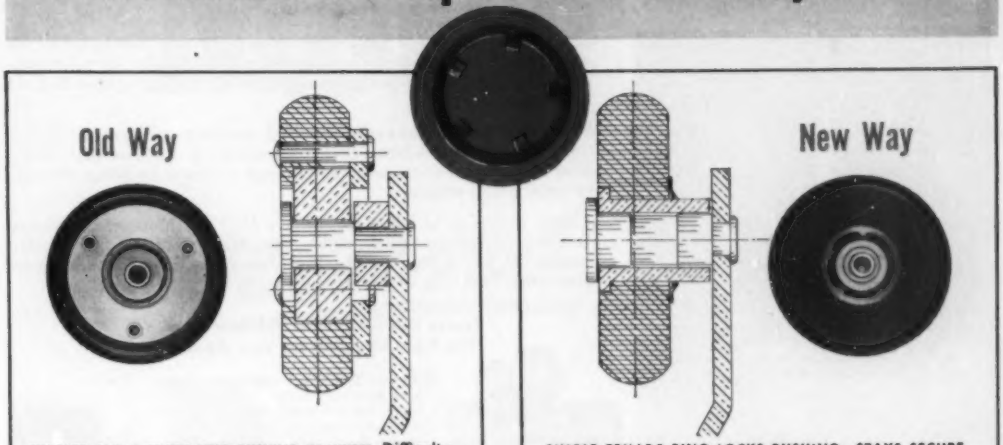
McGRAW-HILL BOOK CO.,
330 W. 42nd St., N.Y.C. 18, N.Y.

Send me the A. S. T. E.'s TOOL ENGINEERS HANDBOOK for 10 days' examination on approval. If the book proves satisfactory, I will remit $5.00 in 10 days, and $3.00 monthly until $15.00 is paid. Otherwise I will return the book postpaid after 10 days. (We pay for delivery if you remit first payment with this coupon; same return privilege.)

Name.....
Address.....
City..... Zone.... State.....
Company.....
Position PE-2-50

This offer applies to U. S. only

Single Truarc Ring Slashes Unit Cost 44% ...eliminates 3 operations and 5 parts



WASHER AND 3 RIVETS HELD BUSHING IN WHEEL. Difficulty in accurate positioning of rivet holes caused rejects. Also rivets loosened in use.

SINGLE TRUARC RING LOCKS BUSHING—STAYS SECURE. Self-locking ring (type 5105) needs no groove. Replaces washer, 3 rivets, separate spacer.

Redesign with one Waldes Truarc Ring cuts cost of wheel used in Har-Vey Rolling Door Hardware (for residential doors) from 26.1¢ to 14.5¢—a 44% saving for Metal Products Corporation, Miami. Use of Truarc cuts manufacturing time 76%. Eliminates 5 separate parts, 3 press operations. And gives a product that stands up better in use!

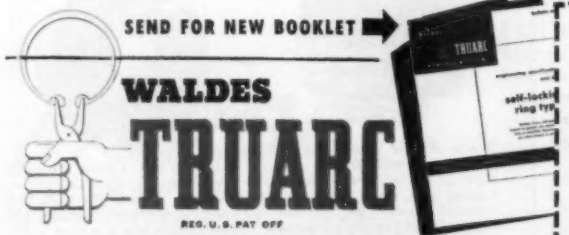
Redesign with Truarc Rings and you too will cut costs. Wherever you use machined shoulders, bolts, screws, nuts, cotter pins, snap rings, there's a Truarc Ring that does a better job of holding parts together. Truarc Rings are precision engineered. They make assembly and disassembly quick and easy.

See what Truarc Rings can do toward cutting overall costs for you. Send your blueprints to Waldes Truarc engineers for individual attention, without obligation.

Redesign with Truarc self-locking ring produces these savings:

	saving
eliminates drilling 3 rivet holes	$.0042
eliminates riveting washer	.0111
eliminates punching washer	.00033
eliminates washer, spacer, rivets	.02236
cuts cost of inserting bushing	.00037
cuts cost of inspection	.0032
cuts cost of wheel, bushing, rivet	.0797
	.12126
less—cost of Truarc Ring	.00528
TOTAL SAVING PER UNIT 44%	$.11598

SEND FOR NEW BOOKLET



WALDES

TRUARC

REG. U. S. PAT. OFF

RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

WALDES TRUARC RETAINING RINGS ARE PROTECTED BY U. S. PATS. 2,302,940; 2,415,052; 2,420,021; 2,411,751 AND OTHER PATS. PEND.

Waldes Kohinoor, Inc., 47-16 Austel Place PN-022
Long Island City 1, N. Y.

Please send Data Book on Waldes Truarc Self-Locking Ring Types.

Name_____

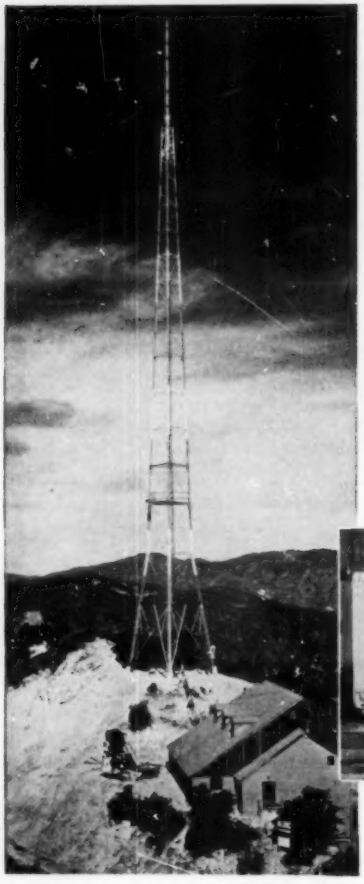
Title_____

Company_____

Business Address_____

City_____ Zone_____ State_____

BASIC FORMULA FOR DESIGN ENGINEERS... M=PT.....

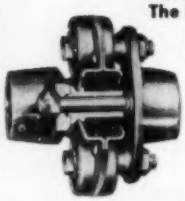


APPLY the formula M = PT (Morse means Power Transmission) to your coupling problems because Morse Chain makes the most complete line of flexible couplings available, all especially adaptable to your design needs.

Front-end power take-offs, flywheel coupling applications, cooling tower drive shafts and Diesel-electric generator sets (as illustrated below) have all proved the successful performance of Morse couplings through exhaustive field service.

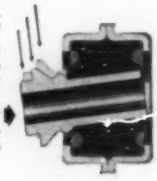
Always remember to follow the formula M = PT (Morse means Power Transmission) for best results on your coupling applications and *all other* mechanical power transmission problems. Morse products are immediately available from your local distributor's stocks.

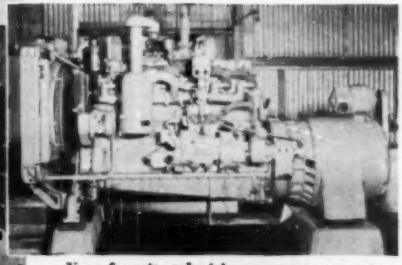
Morse Has 4 Types of Flexible Couplings The Right Coupling for Your Application



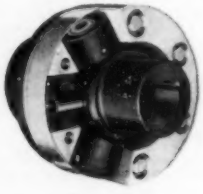
Morse Morflex Couplings, available in single, double and "Junior" types, are torsionally flexible, transmit power smoothly, isolate vibration, absorb shock loads. Require no lubrication or maintenance.

Morflex Couplings compensate for misalignment through elastic deflection of Neoprene "biscuits"—no metal-to-metal contact.





Your favorite television program comes to you from TV transmitters like this one atop Mt. Wilson. Diesel electric sets, equipped with torsionally flexible Morflex Couplings, guarantee the flow of electric current in the event of power-line failure.



Morse Radial Morflex Heavy-Duty Couplings use the same Neoprene "biscuits" assembled radially. All Morflex Couplings are impervious to water, dirt, oil and weather—never require lubrication or maintenance.

CLIP COUPON . . . PASTE ON POST CARD . . . MAIL TO MORSE!

Morse Chain Company
7601 Central Ave., Dept. 505
Detroit 8, Mich.

Please send me latest technical data and specifications on:

Morse Morflex Flexible Couplings ☐ Morse Roller and Silent Chain Flexible Couplings ☐

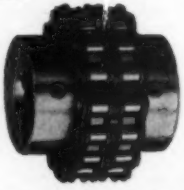
Name _____

Title _____

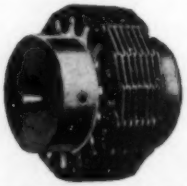
Company _____

Address _____

City _____ Zone ____ State _____

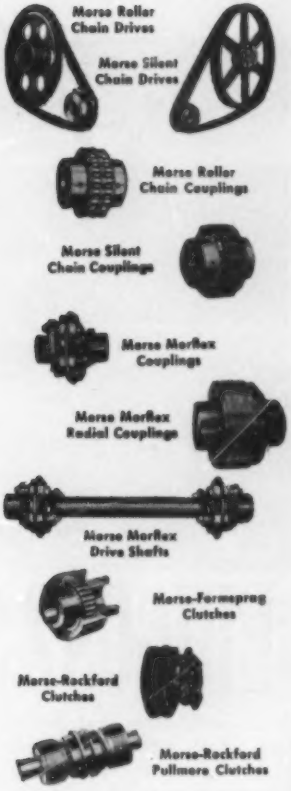


Morse Roller Chain Flexible Couplings, with double chain, have increased chain-sprocket bearing area, are compact, easily installed, durable, low-cost. Morse Roller Chain Couplings compensate for misalignment, provide positive power transmission. Available in wide range of stock and special sizes, with either steel or plastic covers.



Morse Silent Chain Flexible Couplings distribute the load so that unit stresses are small and uniform, service life is longer. The silent chain has a central guide link, which fits between coupling sprockets and centers the chain in relation to the coupling, permitting endfloat and endwise assembly or disassembly. Send coupon.

Morse *means* Power Transmission



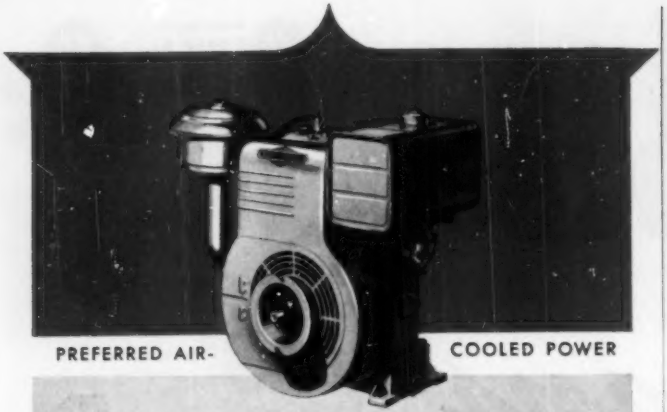
MORSE
MECHANICAL
POWER TRANSMISSION
PRODUCTS

PRODUCTS OF BW BORG-WARNER

Ask the Morse Man for power transmission information!

100 Morse Branch Offices and Distributors to supply your power transmission demands.

From coast to coast there are more than 100 offices, representatives and distributors of Morse Power Transmission products to give you quick information and service when you want it—where you want it. *Ask the Morse Man first in any case!* Check your classified phone directory under **"Power Transmission"** or **"Chains"** for the nearest Morse Man.



PREFERRED AIR- COOLED POWER

It's Powered "RIGHT" when It's Powered by

BRIGGS & STRATTON

Designed "Right" — Built "Right"
The Preferred Power of
Users, Dealers and Manufacturers

The reputation for "dependable" performance established by more than 4 million engines, during a period of over 30 years, has placed Briggs & Stratton as first choice in the field — the "Preferred Air-Cooled Power" the world over.

Let the Briggs & Stratton trademark be your guide to all that is best in 4-cycle, single-cylinder air-cooled gasoline engine performance.

BRIGGS & STRATTON CORPORATION
Milwaukee 1, Wisconsin, U. S. A.

4 CYCLE BRIGGS & STRATTON GASOLINE ENGINES

Preferred Power FOR INDUSTRIAL CONSTRUCTION RAILROAD AND FARM EQUIPMENT

WHEN YOUR DESIGN PROBLEM ↘ calls for a material that is

hard
a good **electrical insulator**
strong
attractive in appearance
clean
heat-resistant with low expansion
resistant to attack by most acids
... and priced right—

well, how about

McKEE GLASS?

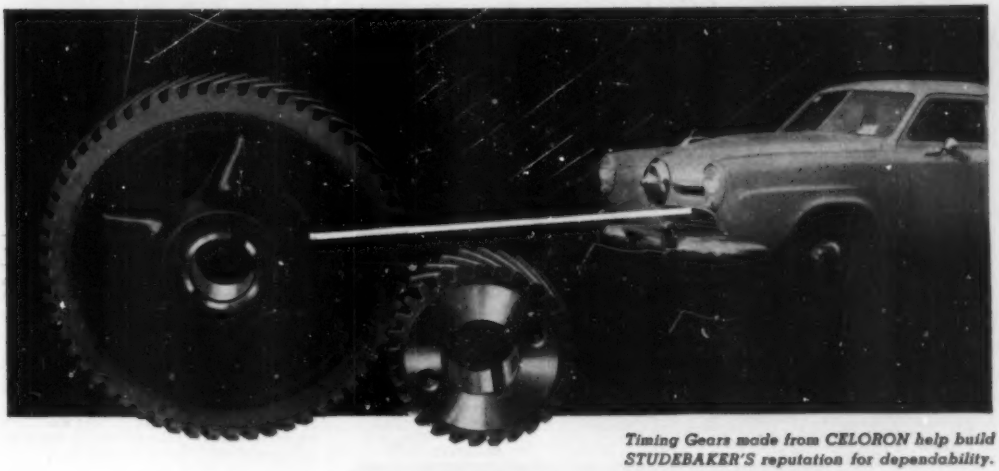
McKee customers benefit by almost 100 years of glass-making experience. McKee makes glass to your design and specifications . . . or works with you in creating new designs . . . new specifications.

Let McKee show you how dozens of companies profit by using McKee glass in many applications—television mirror blanks to mixing bowls, clothes washer windows to godet spinning wheels.

McKEE GLASS COMPANY
ESTABLISHED 1853
PRODUCT DEVELOPMENT DIVISION
JEANNETTE, PA.
MAKERS OF THE WORLD'S MOST COMPLETE LINE OF GLASS COOKING WARE

CELORON

. . . what's in it for you and your products?



Timing Gears made from CELORON help build STUDEBAKER'S reputation for dependability.

What's in CELORON for you . . . and your products? This different thermo-setting plastic maintains strength and resiliency at temperatures up to 290°F. Resists oil, water and many corrosive chemicals. It is 1/6 the weight of steel—only 1/2 the weight of aluminum! Remarkably easy to machine, Continental-Diamond's CELORON gives you an unusual combination of light weight, high strength, and wear resistance *plus* electrical insulating properties.

CELORON is another example why it pays to see C-D first in your search for the right plastic. For plastics that provide *practical* combinations of mechanical and electrical properties, call your nearest C-D office. Trained technicians on hand at all times to help with your material selection problems.

CELORON—ideal for many mechanical and electrical applications

Specific Gravity	1.38	Impact Strength (Izod) (per inch of notch)	2.3 Ft. Lbs.
Tensile Strength	6,500 psi	Brinell Hardness—500 kg. load (10 mm diameter ball—30 seconds)	38
Flexural Strength	10,000 psi		
Compression Strength	25,000 psi		
Shearing Strength	8,500 psi	Rockwell Hardness	M105

DE-1-50

BRANCH OFFICES: NEW YORK 17 • CLEVELAND 14 • CHICAGO 11 • SPARTANBURG, S. C. • SALES OFFICES IN PRINCIPAL CITIES
WEST COAST REPRESENTATIVE: MARWOOD LTD., SAN FRANCISCO 3 • IN CANADA: DIAMOND STATE FIBRE CO. OF CANADA, LTD., TORONTO 8

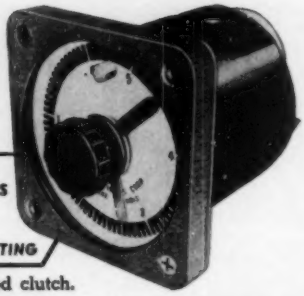
Continental-Diamond FIBRE COMPANY

Established 1895 . . Manufacturers of Laminated Plastics since 1911—NEWARK 40 • DELAWARE

New!

Small, Dependable INDUSTRIAL TIMER

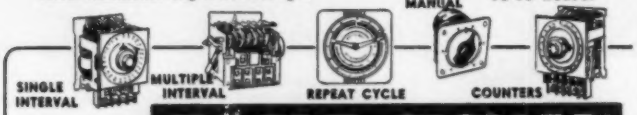
EAGLE Cycl-Flex



ELAPSED TIME INDICATOR
SEALED WINDOW PROTECTS DIAL AND POINTERS
ENCLOSED MECHANISM
FLANGE FOR PANEL MOUNTING

- Positive action insured by toothed clutch.
- Accurate Timing provided by Synchronous motor.
- Auxiliary contacts on clutch solenoid often eliminate separate relays.

Dials available from 30 seconds to 10 hours.



AN EAGLE TIMER FOR EVERY TIMING PROBLEM!

EAGLE SIGNAL CORPORATION Moline Illinois

Micro Ball Bearings

Conrad Radial

The smaller the bearing the better it runs.

In American-made miniature sizes only Micro bearings have *ground* outer rings and raceways.

Write for your copy of Technical Bulletin No. 50 showing RADIAL (Conrad, extra light, and full race), Angular Contact, Self Aligning and Pivot Bearings 1/8" to 3/8" O.D.

New Hampshire Ball Bearings, Inc.
3 MAIN ST. • PETERBOROUGH, NEW HAMPSHIRE

The GROUND Miniature Bearing

FINDS GUIDE

...in NEMA Standards

"This is an excellent guide" is the way Mr. C. Charles Roukas, Electrical Engineer at Cyclotherm Corporation, Oswego, New York, describes the condensation of NEMA Standards on Motors and Generators which is filed in McGRAW-HILL'S PRE-FILED ELECTRICAL CATALOGS.

This is a 16-page section edited especially for USERS, to whom selection of motors and generators guided by NEMA Standards offers benefits such as: assurance of greater availability; more convenience in use; a sounder basis for accurate comparison; prompter repair service and shorter delivery time.

If PRE-FILED ELECTRICAL CATALOGS is not available for buying reference at your plant write to McGRAW-HILL CATALOG SERVICE, 330 West 42nd Street, New York 18, N. Y. There is no charge to qualified users.

NEW STOCK LIST
EVERLASTING FASTENINGS

- Bolts, Nuts, Screws, Washers Rivets, Accessories . . .
- Each in 3 to 10 different non-corrosive metals . . .
- Brass, Bronzes, Copper, Monel and Stainless Steels

OVER 7000 ITEMS

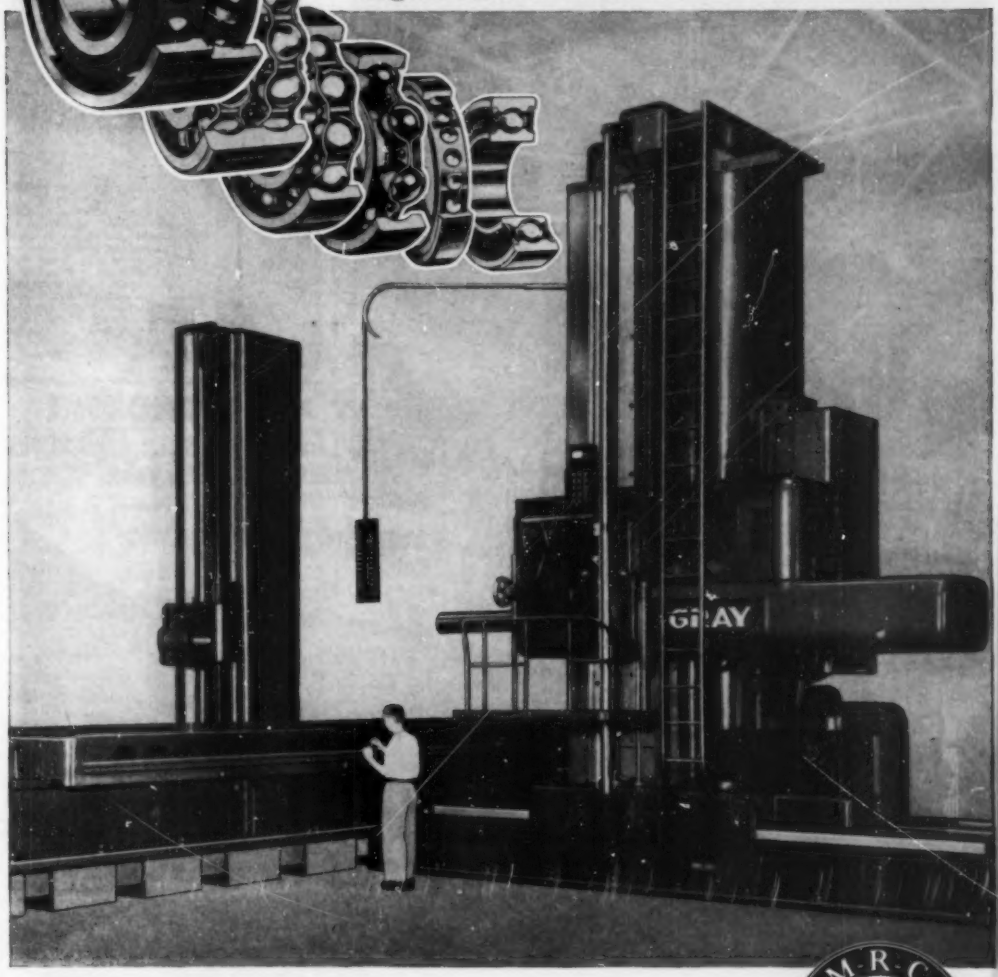
FREE

MAIL COUPON TODAY

Dept. A3
H. M. HARPER CO., MORTON GROVE, ILL.
Please rush your current stock list of non-ferrous and stainless steel fastenings.
Name ..... Title .....
Company .....
Address .....

75 M-R-C Ball Bearings

contribute to the efficiency of one of the largest machine tools built in recent times

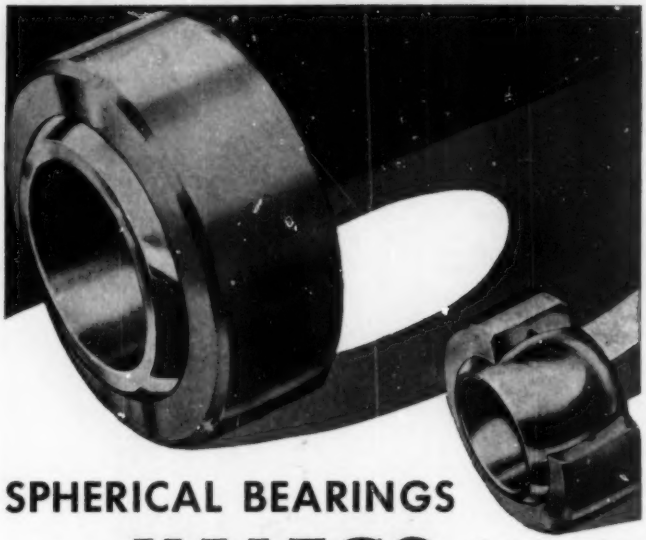


New GRAY 8′ PLANER-TYPE HORIZONTAL BORING, DRILLING AND MILLING MACHINE.
This 175 ton machine is capable of supporting castings weighing 85 tons.
Manufactured by G. A. Gray Co., Cincinnati, Ohio for Hydraulic Press Mfg. Co., Mt. Gilead, O.

M-R-C Strom SRB GURNEY BALL BEARINGS

MARLIN-ROCKWELL CORPORATION
Executive Offices: JAMESTOWN, N. Y.

SELF-ALIGNING HI-LOAD



SPHERICAL BEARINGS by HALFCO

Bore Sizes from 3/16th to 3 Inches

HAVE BEEN USED IN ALL TYPES OF INDUSTRY FOR MORE THAN FIVE YEARS . . . *If your application or problem involves HI-LOAD, MISALIGNMENT, VIBRATION or SHOCK, a HALFCO BEARING is your answer . . .*

HALFCO BEARINGS, formerly manufactured by Adel Precision Products Co., are now manufactured exclusively by HALFCO

NOW COMPETITIVELY PRICED

Send orders, inquiries, etc., to

HALFCO
BEARING DIVISION
of MARSAM ENTERPRISES, Inc.

EXECUTIVE OFFICES
211 So. Beverly Drive • Beverly Hills, Calif.

FACTORY
812 So. Flower St. • Burbank, Calif.

DON'T GO HALFWAY!! GO HALFCO!!

ANALYSIS AND LUBRICATION OF BEARINGS

1. Here are the most recent developments and procedures in bearing analysis and lubrication. Covers general principles of bearing load analysis, hydrodynamic lubrication, etc. Takes up aircraft-engine bearing loads, journal bearings, high speed considerations, rolling contact bearings, bearing evaluation, etc. Includes such topics as high speed bearing stability, bearing erosion, etc., and analyzes recently developed types and arrangements. **By M. C. Shaw, M.I.T., and E.F. Macks, Mech. Eng., 618 pages, $10.00.**

ANALYTICAL MECHANICS OF GEARS

2. This book treats the whole field of transmission of motion and power by means of gears, pointing the way to design of more effective gears for every purpose. Covers spur and helical gears on parallel shafts . . . bevel and spiral bevel gears on intersecting shafts . . . and spiral, worm and hypoid gears on non-parallel and non-intersecting shafts. Provides analytical solution of gear tooth forms and important material on gear teeth in action. **By E. Buckingham, M.I.T. 540 pages, $10.00.**

OIL HYDRAULIC POWER And Its Industrial Applications

3. This new book covers the latest practice in hydraulic components, oil circuits and applications. It stresses the development, theory and applications of oil hydraulics—discusses all aspects of fluid mechanics as applied to oil under pressure . . . its flow characteristics, viscosity and behavior in hydraulic machinery. Includes material on the generation and utilization of oil hydraulic power, and practical design, construction, operation and maintenance techniques. **By Walter Ernst, Consulting Eng. 366 pages, $6.00.**

ALUMINUM AND MAGNESIUM DESIGN AND FABRICATION

4. Here is the information you need to product articles from aluminum and magnesium. Designers, engineers, manufacturers, production men . . . everyone engaged in metalworking will find this book a valuable tool. Discusses alloys, basic stress and strain, hand and power tools, rubber hydraulic press, contour roll forming, etc. Practical shop techniques are fully covered as well as design principles and applications and cost analysis. **By R. Burt Schutze, Glenn L. Martin Co. 589 pages, $7.50.**

SEE THESE BOOKS 10 DAYS FREE

McGraw-Hill Book Co., Inc.,
330 W. 42nd St., N. Y. 18, N. Y.

Send me book(s) corresponding to numbers encircled below for 10 days' examination on approval. In 10 days I will remit for book(s) I keep, plus few cents for delivery, and return unwanted books postpaid. (We pay for delivery if you remit with this coupon; same return privilege.)

1 2 3 4

Name .....

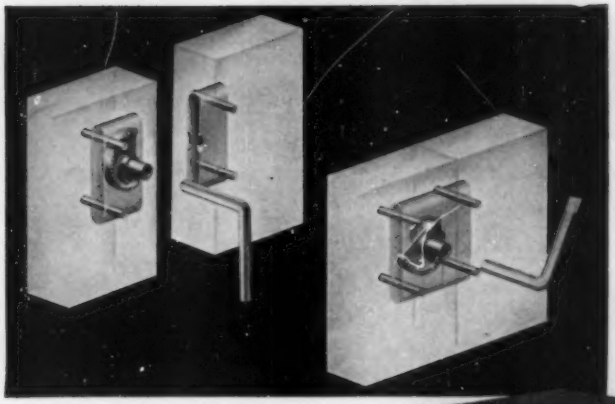
Address .....

City ..... Zone..... State.....

Company .....

Position PE-2-50

This offer applies to U.S. only.



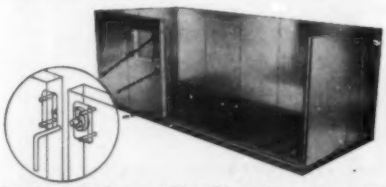
Serrated, tapered cam in male component engages lip of female. Panels are drawn tightly together when cam is turned by hex wrench, screwdriver, or any hand tool.

Lightweight box with Roto-Lock Fastener may be knocked down to greatly reduced bulk. Sections can be stocked for easy shipping.

PHOTO, COURTESY UNITED STATES PLYWOOD CORPORATION

New Roto-Lock Fasteners Solve Demountable Panel Problems

This portable shelter is made of honeycomb panels developed by the U. S. Plywood Corporation. All panels are attached with Roto-Lock Fasteners. They are also used in similar structures by the White Aircraft Corporation, McLaughlin Research Corporation, and Metcalf & Eddy.



Panels of this demountable refrigeration unit, made of insulated honeycomb, are Roto-Lock attached. C. V. Hill & Co., Inc., and U. S. Plywood Corporation are using the fastener in this way.

Panels of any material—equipped with the new Simmons Roto-Lock—can be fastened quickly and securely either at right angles or butt joint. No skill is required—just turn the tapered cam to lock, then turn again to unlock. Check these features of Roto-Lock...

1. Roto-Lock exerts sufficient pressure to form airtight and watertight seal when gaskets are used between panels. Carries high-tension loads as well as heavy shear loads—providing a completely structural, insulated connection.
2. Recesses completely into panels—no protruding parts.
3. Will fasten in seriously misaligned conditions—locks in any semi-open position.
4. No springs or delicate mechanical parts which may be affected by severe temperature conditions or field service.

Portable shelters, air freight and cold-storage shipping containers, walk-in coolers, demountable furniture, scaffolding, and many other designs where demountability is desirable, are using this versatile fastener. All are illustrated in our literature. Write for your copy today.

Simmons Fastener Corporation
1751 NORTH BROADWAY, ALBANY 1, N. Y.

QUICK-LOCK...
SPRING-LOCK...
ROTO-LOCK...

It's a Simple Story...

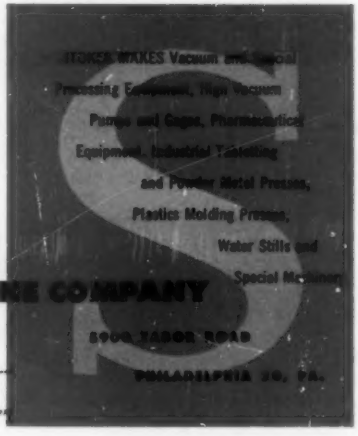
...**"POWDER METALLURGY TODAY"**

... because it is a relatively brief summary—a quick, but broad and thoughtful view—of the field of Powder Metallurgy.

Only 23 minutes to read ... the brochure has pertinent data and illustrations ... all on powder metallurgy and its diverse applications in industry.

Truly authoritative yet so simply written as to be fully informative to designers whose experience has heretofore been confined to the older methods of forming metal.

Fill in the coupon...tear it from the page ... and mail NOW... a copy will be sent with our compliments.



FJS **F. J. STOKES MACHINE COMPANY**

F. J. STOKES MACHINE CO.
5900 TABOR ROAD
PHILADELPHIA 20, PA.

Please ... a copy of "POWDER METALLURGY Today"

NAME ..... TITLE .....

COMPANY .....

ADDRESS .....

CITY ..... ZONE ..... STATE ..... QP

Another typical aircraft forging by Wyman-Gordon — with an over-all measurement of more than 45" this intricate alloy steel forging is a vital wing support for a modern military bomber. For applications of such importance the best technique known in forging practice is essential, assuring scale-free surfaces, close dimensional tolerances, uniform minimum weight and maximum strength — There is no substitute for Wyman-Gordon experience.

Standard of the Industry for More Than Sixty Years

WYMAN-GORDON

Forgings of Aluminum, Magnesium, Steel

WORCESTER, MASSACHUSETTS, U. S. A.

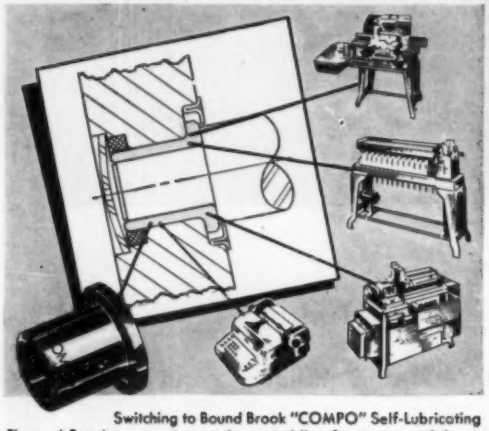
HARVEY, ILLINOIS - - - DETROIT, MICHIGAN

"COMPO" OIL-RETAINING POROUS BRONZE BEARINGS

Why Nationally-Known Business Machine Manufacturers* Use "COMPO"

SELF-LUBRICATING BEARINGS

*Names on request



Switching to Bound Brook "COMPO" Self-Lubricating Flanged Bearings meant more than providing for severe end thrust. It meant:

To the manufacturers:

- *Simplification of design, quicker, lower cost assembly and elimination of costly machining operations.*

To end users:

- *No periodic lubrication, maintenance costs cut, and continuous, quiet, trouble-free operation.*

"COMPO" Porous Bronze Bearings are made from pure metal powders, die-formed to shape, alloyed at high temperatures, finished to exact dimensions, and vacuum-impregnated with lubricant. Self-lubricating qualities make them ideal for use in inaccessible spots. The lubricant is sealed in, free from dirt, and an even lubricating film is always present.

Thousands of "COMPO" Bearing sizes can be made from existing dies; hundreds of sizes in stock for prompt shipment. Use coupon below, to get our free Stock List or arrange a conference with one of our engineers. *We've saved time and costs for others; we can do the same for you.*

Many other types of "COMPO" Bearings and "COMPO" structural parts have been designed into business machines, appliances and other types of equipment at equal savings and with equal performance benefits.

BOUND BROOK OIL-LESS BEARING COMPANY

BEARINGS • BUSHINGS WASHERS • PARTS

BOUND BROOK, N. J. ESTABLISHED 1883

Bound Brook Oil-Less Bearing Co.
Bound Brook, N. J. PE 2-50

☐ I would like to talk to one of your engineers about_____

☐ Please send me a copy of your "COMPO" Bearing Stock List.

Name_____ Title_____

Company_____

Street_____ City_____ State_____

1950 NATIONAL PLASTICS EXPOSITION

CHICAGO
NAVY PIER
•
MARCH 28-31
1950

For designers, production men, sales executives, merchandise men and buyers in all industries and businesses. See all the latest advances in the world of plastics. See how to use plastics in all forms, old and new — to stimulate the sale of *your* products. Over 100 exhibits, showing materials, machines, finished products. Consult with the experts — they'll be there!

Guest Tickets: This exposition is not open to the public. Guest tickets are available free on request by writing (on your company letterhead) to —

THE SOCIETY OF THE PLASTICS INDUSTRY, INC.
295 MADISON AVENUE, NEW YORK 17, N. Y.

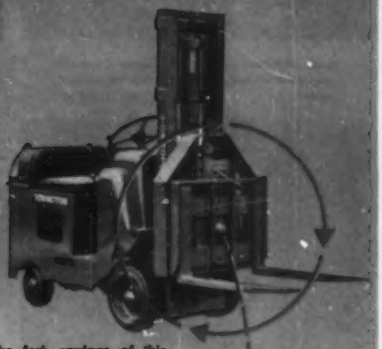
Which of These
ROCKFORD CLUTCHES
Will Solve Your Power Control Problem?

Avoid the waste of trial-and-error testing. A letter or phone call to our engineering department will save you weeks of vital time and give you the benefit of their quarter-century of experience transmitting and controlling power — with clutches. Their know-how, plus a wide range of clutch types and sizes to choose from, will help your engineers specify the RIGHT clutch for YOUR product.

ROCKFORD CLUTCH DIVISION
BORG-WARNER
209 Catherine Street, Rockford, Illinois

Another Job for Pesco HYDRAULIC MUSCLES

DUMPING MULTI-TON LOADS IN 5 SECONDS



The fork carriage of this Towmotor model revolves 360 degrees in either direction.

The hydraulic motor which revolves the Towmotor carriage has a displacement of 1.0 cu. in. and develops 14.5 in.-lbs. torque per 100 p.s.i.

This Pesco hydraulic pump which develops the power for the above motor has a displacement of .577 cu. in. Capacity: 3.3 g.p.m. @ 1500 r.p.m. at 1000 p.s.i.

● One of industry's most effective material handling time-savers is Towmotor's fork lift truck with the revolving carriage. With it a man can quickly and easily transfer heavy loads of solid, liquid, or granular material from one container to another.

The ingenious device that revolves the fork carriage in a 360-degree circle, in either direction, is actuated by a Pesco hydraulic motor so small it will fit snugly into the palm of your hand. Yet it is so powerful it will flip loads up to three tons completely over in five seconds!

Towmotor is one of the rapidly growing number of industrial equipment manufacturers who are turning to Pesco for answers to their hydraulic problems. They have found that the skills and precision craftsmanship that Pesco has developed to meet the exacting requirements of the military and civilian aircraft manufacturers insure the high quality and trouble-free operation they demand in their own products.

Perhaps the sales power of hydraulic power can help you, too. If you have a problem in squeezing, gripping, lifting, holding, or turning heavy loads with precise accuracy and finger-tip control, why not let Pesco engineers suggest a solution.

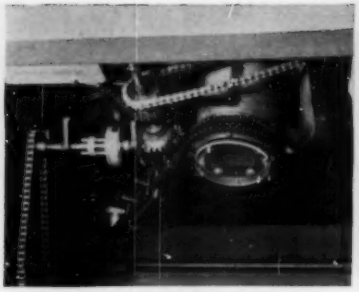
A preliminary discussion will involve no obligation.

engineering Pesco production

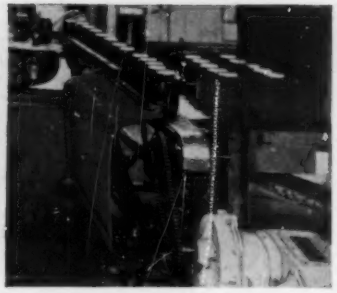
PRODUCTS DIVISION

BORG-WARNER CORPORATION

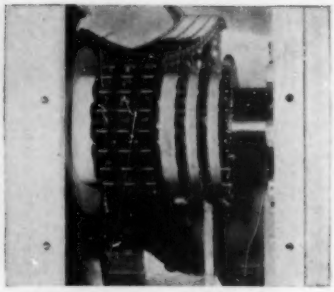
24700 NORTH MILES ROAD BEDFORD, OHIO



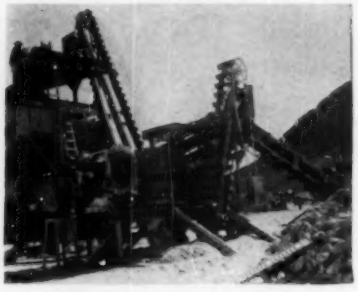
Baldwin-Rex ¼-inch pitch Roller Chain is used to transmit power in this micro-film reader.



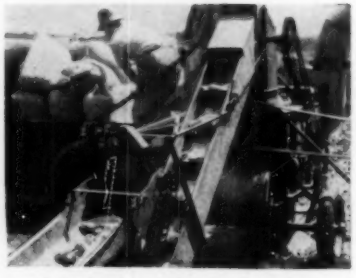
Rex Table Top Chain handles bottles through this filling machine.



Both Rex Offset Side Bar Roller Chain and Baldwin Roller Chain are used to transmit power in drilling rigs.



Rex Durobar Combination Chain is used in these bucket elevators handling crushed stone.



Economical Rex Steel Detachable Chain is used in this corn sheller.

1000 Chains

to cut costs, save space, increase machine

Did you know there were that many sizes and types of chains? There are . . . in the complete Chain Belt Line . . . and it's an important fact to know if you're interested in designing for lower costs, both first and operating!

No one type of chain is equally efficient for all power transmission, timing or conveying functions. A finished steel roller chain is ideal for high speed power transmission, but a steel Chabelco Chain will deliver more where speeds are slow, operating conditions severe and economy important. Or, suppose the conditions involve corrosive or abrasive service. A Rex Cast Chain in either malleable iron or Rex Z-Metal is a better choice. Perhaps the problem in-

CHAIN BELT DISTRICT OFFICES

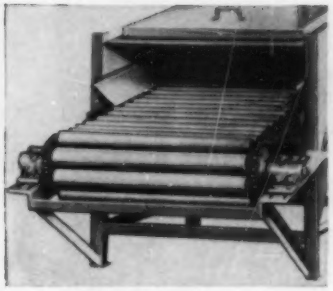
Atlanta	Detroit	Milwaukee	St. Louis
Birmingham	Houston	Minneapolis	San Francisco
Boston	Indianapolis	New York	Seattle
Buffalo	Jacksonville	Philadelphia	Springfield
Chicago	Kansas City	Pittsburgh	Tulsa
Cincinnati	Los Angeles	Portland	Worcester
Cleveland	Louisville	Richmond	
Dallas	Midland	Salt Lake City	

CHAIN BELT REX COMPANY

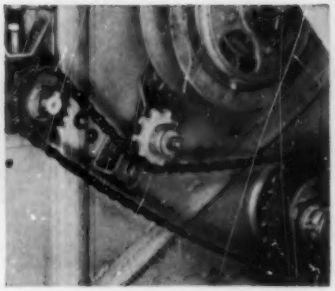
CHAIN BELT COMPANY—

REX CHAIN & TRANSMISSION DIVISION
Milwaukee 4, Wisconsin

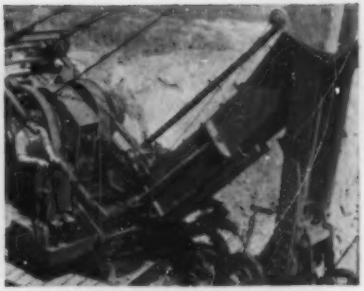
BALDWIN-DUCKWORTH DIVISION
Springfield 2, Massachusetts



REX Pintle Chains are used with wooden carrier rolls in this Roller Scalder.



Baldwin-Rex Double Pitch Roller Chains drive the conveyors on a harvesting machine.



Rex Steel Chabaico Chains are used in this shovel and in many other types of construction machinery.

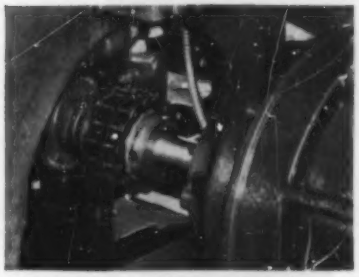
for 1001 Ways

efficiency, improve product appearance!

volves the conveying of bottles, jars or cans. Rex Table Top Chain or Baldwin-Rex Plate Top Chain is the best solution here.

That's why it will pay dividends in lower first and operating costs if you carefully consider the matter of power transmission, timing or conveying in your designs. And, it will pay you to talk over your chain application problems with a Chain Belt Field Sales Engineer. Because he handles a complete line of chain, he can recommend, without prejudice, the exact chain for your needs. Call or write the Chain Belt Field Sales Office near you or, if you prefer, mail the coupon below.

Baldwin-Rex Roller Chains supply the right combination of high strength and light weight for this lift truck.



Baldwin-Rex Roller Chain Flexible Couplings provide true flexibility without backlash.

THE COMPLETE CHAIN BELT LINE

Baldwin-Rex Roller Chains
Baldwin-Rex Double Pitch Roller Chains
Baldwin-Rex CPS Plate Top Chains
Rex Cast & Steel Detachable Chains
Rex Pintle Chains
Rex H-Type Drive Chains
Rex H-Type Conveyor Chains
Rex Refuse & Log Haul Chains
Rex Transfer Chains
Rex Ley Bushed Chains
Rex Combination Chains
Rex Durabar Chains
Rex Cast Roller Chains
Rex Double-Flex Chains
Rex Sugar Mill Chains
Rex Chabaico Steel Chains
Rex Offset Side Bar Roller Chains
Rex Table Top Conveyor Chains
Rex Drop Forged Chains
Rex Drag Chains
Rex Cast Sprockets
Baldwin-Rex Cut Tooth Sprockets
Baldwin-Rex Flexible Couplings and a complete line of chain attachments.

BALDWIN·REX

CHAIN BELT COMPANY
1715 West Bruce Street
Milwaukee 4, Wis.

Gentlemen:

I am particularly interested in.....

( ) Please send me descriptive bulletins.

( ) I would like to have a Rex Field Sales Engineer call on me regarding my chain application problems.

Name.....

Company.....*Dept*.....

Address.....

City.....*State*.....

THE ONLY WAY YOU CAN BEAT FORGINGS AS A SALES FEATURE IS TO USE MORE FORGINGS

A REFERENCE BOOK ON FORGINGS FOR ALL USERS OF METAL PARTS

60 pages of authoritative information on metal quality as developed in forgings formed through the use of closed impression dies. Forging production techniques are described and illustrated; economic advantages of forgings are presented from the viewpoint of top management, design engineers, metallurgists and production executives. Your copy is ready. Fill in and attach coupon below to your business letterhead.

● What a forging *has*—can't be duplicated! No other method of fabricating parts utilizes fully the fiber-like flow line structure of wrought metals. Thus, forgings provide matchless capacity for the toughest work loads and fortify your product for better performance. Forgings forestall and reduce downtime due to failure of highly stressed parts; provide a factor of greater safety for men and machines. A recheck of every stressed part, as well as simple handles and levers, frequently reveals opportunities to improve a product, to reduce the cost of machining and finishing or to speed up assembly. Consult a forging engineer—only a forging engineer can inform you fully regarding the many quality advantages and cost-reducing possibilities that are obtainable with forgings.

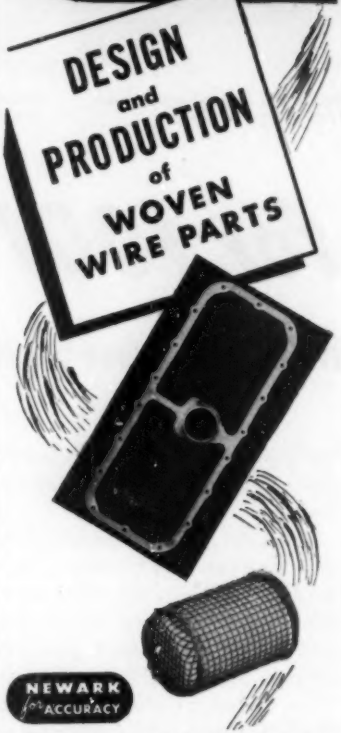
DROP FORGING ASSOCIATION
605 HANNA BUILDING
CLEVELAND 15, OHIO

Please send 60-page booklet entitled "Metal Quality—How Hot Working Improves Properties of Metals", 1949 Edition.

NAME_____
POSITION_____
COMPANY_____
ADDRESS_____

NEWARK

DESIGN and PRODUCTION of WOVEN WIRE PARTS



NEWARK for ACCURACY

Why not allow us to do a "from start to finish" job on your fabricated wire cloth parts? What do we propose to do? Assist you with the design, set up the necessary tooling, make the wire cloth . . . it's the well known Newark Wire Cloth long noted for its accuracy and durability . . . and do all the necessary cutting, stamping, punching, welding, soldering, seaming and bending. We deliver to you a finished product in any quantity desired. We are equipped to handle your requirements on a quantity production basis. May we quote on your next requirements?

* * *

We also manufacture a complete line of industrial wire cloth in all commercial malleable metals.

Newark Wire Cloth COMPANY
143 VERONA AVENUE • NEWARK 4, NEW JERSEY

There's a Century MOTOR To Supply Dependable Power For All Popular Applications

Century motors are available in sizes from 1/6 to 400 horsepower, in a wide range of types and kinds—single phase and polyphase alternating current, and direct current. All of them are rugedly built to assure top performance throughout a long service life.

POLYPHASE

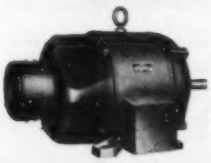
Type SC—OPEN PROTECTED—Form J, general purpose motor—meets the needs for most installations where operating conditions are relatively clean and dry. The top half of the motor frame is closed to keep out falling solids or dripping liquid.

Type SC—SPLASH PROOF—gives the necessary protection where plants must be washed down—keeps water out of the motor even when a hose is applied directly on the frame. Also provides protection against rain, snow, sleet and ice for outdoor installations.

Type SC—TOTALLY ENCLOSED FAN COOLED—protects against dusts, mist or fog detrimental to the vital parts of the motor. The inner frame protecting the motor is sealed to keep out harmful matter.

Type SC—EXPLOSION PROOF protects against atmospheres charged with explosive dusts or gases. They carry Underwriters' label for specific kinds of hazards.

Type SR—SLIP RING—wound rotor motors are suitable for applications requiring low starting current with high starting torque, reversing, or adjustable speed.



Type SY—SYNCHRONOUS MOTORS—suitable for continuous operation at a uniform load for power factor correction.

SINGLE-PHASE

Type RS—REPULSION START INDUCTION—single phase brush lifting motor suitable for applications requiring high starting torque with low starting current.

Type CSH—CAPACITOR START INDUCTION—single phase motor suitable when high starting torque with normal starting current is required.

Type SP—SPLIT PHASE, INDUCTION—single phase motors—suitable for light starting duty.

DIRECT CURRENT

Type DN—DIRECT CURRENT MOTORS—suitable for use where direct current is available or its use desirable.

These illustrations are typical of Century's complete line of motors. Others available include gear motors, generators, AC and DC motor generator sets.

Specify the right Century motor for all your electric power requirements.

Popular types of standard ratings are generally available from factory and branch office stocks.

CENTURY ELECTRIC COMPANY

1806 Pine Street
St. Louis 3, Missouri

Century MOTORS

645

At your Service

ON WIRE AND METAL ASSEMBLIES

CAMBRIDGE offers the most modern fabricating facilities plus years of engineering experience

. . . to make any wire and sheet metal tray, rack, basket, fixture, crate, screen or other fabrication you need to reduce costs and speed-up material handling, processing and treating. The fact that Cambridge is equipped to perform every step of the designing and manufacturing assures you of the famous Cambridge quality and service on all items, regardless of size or quantity.

Your Cambridge field engineer can recommend the right design and construction, and the proper metal or alloy for washing, spraying, dipping and similar operations.

Or write direct for information on the complete Cambridge facilities. Send for this FREE illustrated folder describing Cambridge wire baskets and specialties.

Cambridge Wire Cloth Co.

Department P
Cambridge 2, Md.

Wire cloth in rolls. | Any metal or alloy, mesh or weave.

OFFICES IN PRINCIPAL INDUSTRIAL CITIES
See "Baskets, Wire" in your Classified Telephone Directory

Hand in Hand

A quick glance over the list of our long-time customers shows that many of the larger ones started small. That's why we make it a continuing policy *to give the same close attention to every order, regardless of size.*

You'll never have a gear problem too small to interest us. For, in our forty-five years of manufacturing and selling gears of all types, it has become increasingly evident that good *service to all and our future business success*—go hand in hand.

THE EARLE GEAR & MACHINE CO., 4707 Stenton Ave., Philadelphia 44, Pa. Sales Offices: New York City; Youngstown, Ohio.

It's good business to do business with EARLE.

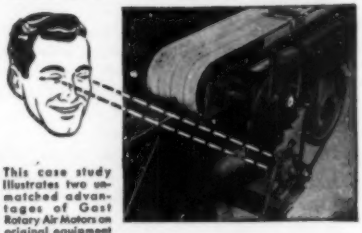
EARLE GEARS

PROBLEM: Drive a conveyor-belt carrying fragile material so that belt speed drops when drag of load increases.

SOLUTION: A Gast Air Motor maintains constant tension on material in process despite varying drag of load and belt r.p.m.

RESULT: This variable-speed drive reduces material spoilage—saves money.

UNUSUAL CONVEYOR-BELT PROBLEM solved with a variable-speed GAST AIR MOTOR



This case study illustrates two unmatched advantages of Gast Rotary Air Motors on original equipment applications. More advantages:

AIR MOTORS CAN'T BURN OUT—It's possible to stall them—but they can't burn out!

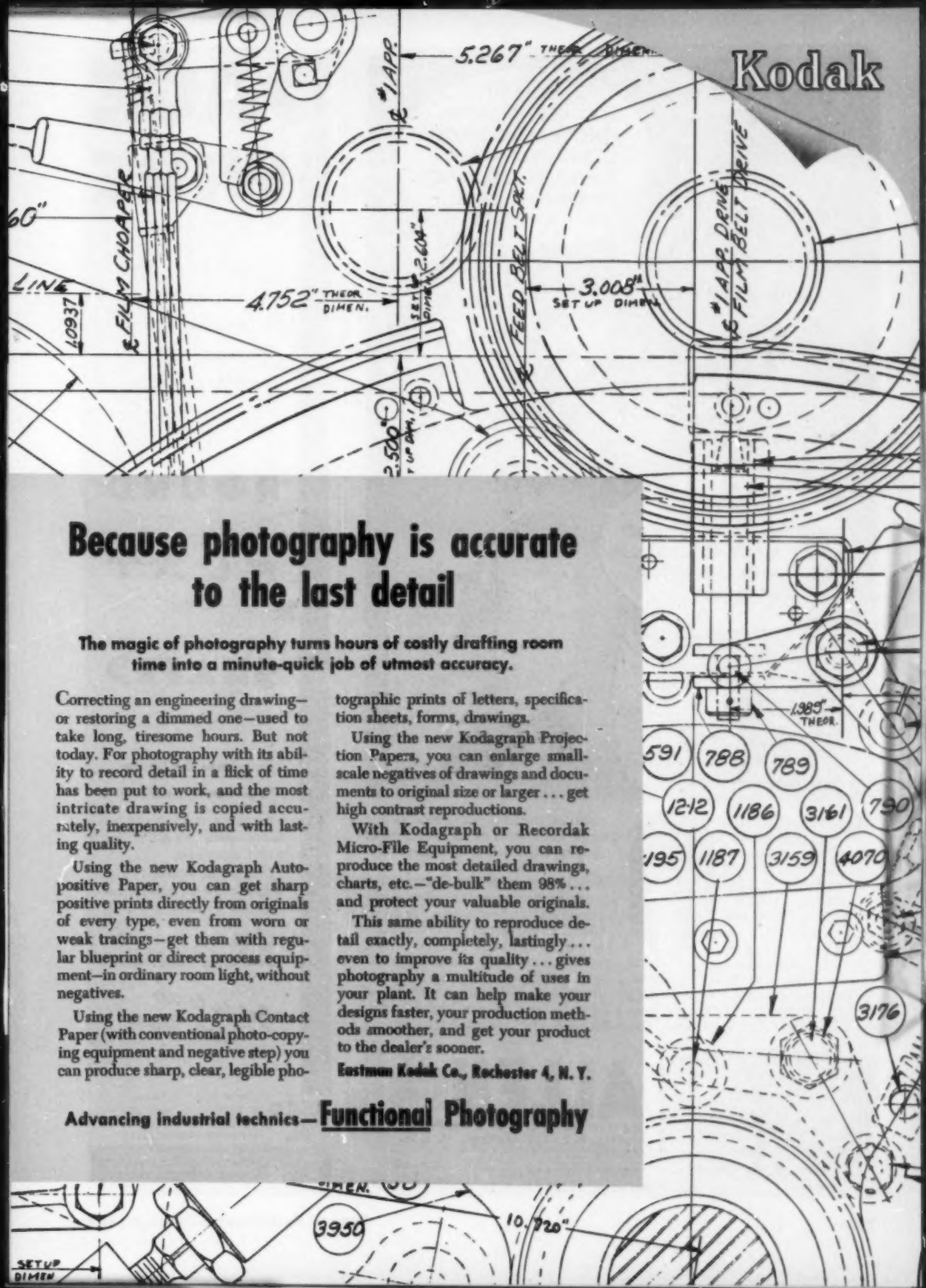
CAN'T SPARK EXPLOSIONS—No sparks—Gast Motors are explosion-proof.

GIVE VARIABLE R.P.M.—Controlled speed from 100 to 2,000—some to 6,000 r.p.m.

In many other ways, Gast Air Motors offer more—at less cost. Investigate now. "Air may be your Answer!"

WRITE TODAY! Request your copy of GAST'S IDEA-CATALOG

GAST ROTARY — AIR MOTORS • COMPRESSORS • VACUUM PUMPS
(TO ONE H.P.) (TO 20 LBS.) (TO 28 INCHES)
GAST MANUFACTURING CORP., 139 Shirley St., Benton Harbor, Mich.



Because photography is accurate to the last detail

The magic of photography turns hours of costly drafting room time into a minute-quick job of utmost accuracy.

Correcting an engineering drawing—or restoring a dimmed one—used to take long, tiresome hours. But not today. For photography with its ability to record detail in a flick of time has been put to work, and the most intricate drawing is copied accurately, inexpensively, and with lasting quality.

Using the new Kodagraph Autopositive Paper, you can get sharp positive prints directly from originals of every type, even from worn or weak tracings—get them with regular blueprint or direct process equipment—in ordinary room light, without negatives.

Using the new Kodagraph Contact Paper (with conventional photo-copying equipment and negative step) you can produce sharp, clear, legible photographic prints of letters, specification sheets, forms, drawings.

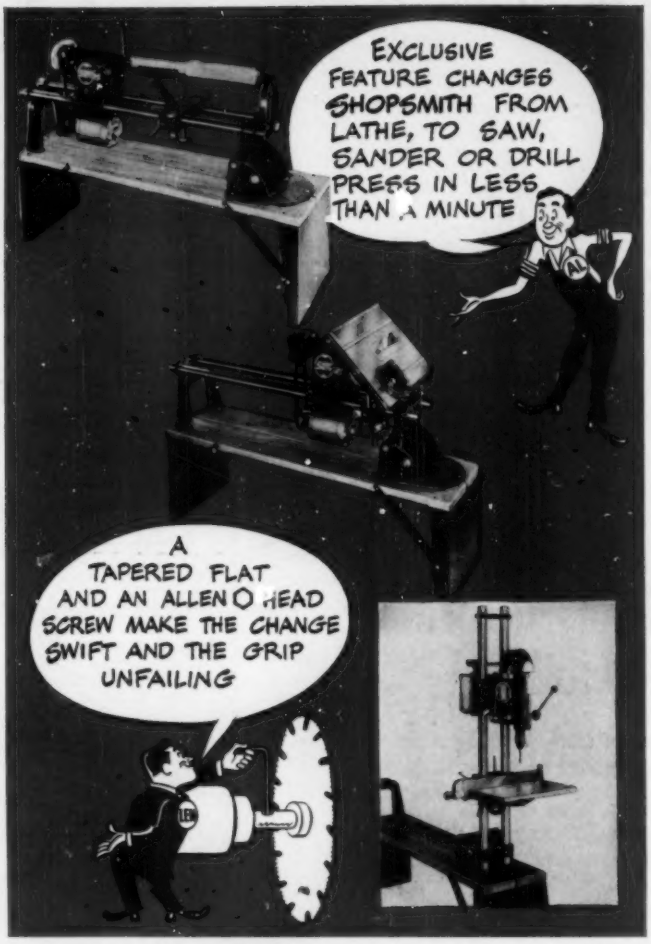
Using the new Kodagraph Projection Papers, you can enlarge small-scale negatives of drawings and documents to original size or larger . . . get high contrast reproductions.

With Kodagraph or Recordak Micro-File Equipment, you can reproduce the most detailed drawings, charts, etc.—"de-bulk" them 98% . . . and protect your valuable originals.

This same ability to reproduce detail exactly, completely, lastingly . . . even to improve its quality . . . gives photography a multitude of uses in your plant. It can help make your designs faster, your production methods smoother, and get your product to the dealer's sooner.

Eastman Kodak Co., Rochester 4, N. Y.

Advancing industrial technics—Functional Photography


EXCLUSIVE FEATURE CHANGES SHOPSMITH FROM LATHE, TO SAW, SANDER OR DRILL PRESS IN LESS THAN A MINUTE
A TAPERED FLAT AND AN ALLEN HEAD SCREW MAKE THE CHANGE SWIFT AND THE GRIP UNFAILING

Magna Engineering Corporation of San Francisco standardizes on Allen Head screws and is using more than a million a year for SHOPSMITHS and SHOPSMITH attachments. A particularly important application is the use of Allen Head Set Screws to fasten the various attachments to the spindle tip. With more than 30,000 SHOPSMITHS sold the manufacturer has yet to receive one single complaint of an attachment accidentally coming off the spindle.

Where there's an application for a precision fastening the safest, most economical answer is the use of an Allen Head screw. This is particularly true when the screw must retain its smooth threading and holding power after long repeated wrenching. *Sold only thru leading distributors.* Write the factory direct for technical information.

WARNING
Allen-Type screws aren't necessarily Allen-Made. Get genuine Pressur-formed Allen Head screws in this black and silver box.

ALLEN ALLEN HEAD
MANUFACTURING COMPANY
Hartford 2, Connecticut, U. S. A.
NEW YORK, CLEVELAND, DETROIT, CHICAGO, LOS ANGELES

FOR 40 YEARS THE BUY-WORD FOR SOCKET SCREWS

PAGE WIRE

LOW CARBON
HIGH CARBON
STAINLESS
SPECIAL ALLOY
ARMCO IRON

ROUND
FLAT
OR
SHAPED

You draw the Shape
—Page can draw the Wire

—the way you want it for your production—whether it's ALL of your product, or only a part.

Cross-sectional areas up to .250" square; widths to ⅜"; width-to-thickness ratio not exceeding 6 to 1.

for Wire or Information about Wire—

Get in touch with Page!

ACCO
Monessen, Pa., Atlanta, Chicago, Denver, Detroit, Los Angeles, New York, Pittsburgh, Philadelphia, Portland, San Francisco, Bridgeport, Conn.

PAGE STEEL AND WIRE DIVISION
AMERICAN CHAIN & CABLE

Quantity
PRODUCTION
of
GREY IRON CASTINGS

ONE OF THE NATION'S
LARGEST AND MOST MODERN
PRODUCTION FOUNDRIES

ESTABLISHED 1866

THE WHELAND COMPANY

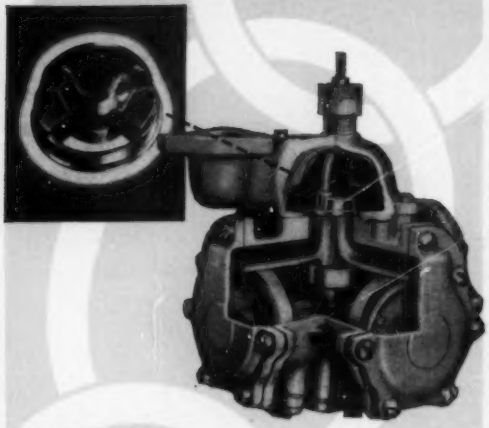
FOUNDRY DIVISION

MAIN OFFICE AND MANUFACTURING PLANTS

CHATTANOOGA 2, TENNESSEE

PROBLEM:

To supply a rotary valve for gasoline meters that would slash normally high maintenance costs and eliminate inaccuracy in meter measurements.



SOLUTION:

Morganite developed and tested a self lubricating rotary valve suitable for gasoline metering. Tests indicated a 90% reduction in operating troubles due to friction, gumming or sticking.

MORGANITE
SELF-LUBRICATING
LIQUID METER VALVES

SEE OUR CATALOG IN SWEET'S FILE

FOR DETAILED INFORMATION consult the Morganite Catalog in Sweets File for Product Designers; for engineering counsel or specific proposals call Morganite

Placed in actual service, results were even better than anticipated. Sticking and friction caused by wax and gumming deposits—the cause of inaccurate measurement and service failures—were reduced to the vanishing point. Morganite dry lubrication is effecting savings and solving "insoluble" problems in all phases of the mechanical, electrical and processing industries.

REGISTERED TRADE MARK

Morganite INCORPORATED

LONG ISLAND CITY 1, NEW YORK

Manufacturers of Morganite Carbon Brushes for all motor and generator applications, and Morganite Carbon Piles.

What happens TO A LUBRICANT AS THE JOURNAL GATHERS SPEED ?

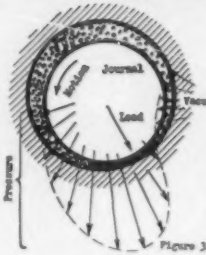


Figure 31

Figure 31 on page 30 of POBCO's new "Design Data" manual shows diagrammatically the forces acting between journal and bearing at normal operating speeds.

To aid engineers and machine designers in solving many basic problems on all bearing applications, POBCO has just published its "Design Data" manual.

Treating the effects of loads, friction, lubricants, circular motion, and heat with all their implications, "Design Data" supplies invaluable information never before available.

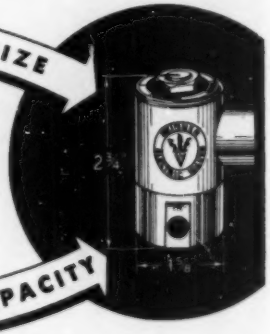
If you're interested we'll be glad to loan you a copy. No obligation, just write.

PARAMOUNT OILLESS BEARING CO., INC.
99 Hope Avenue, Worcester, Mass.

SMALL IN SIZE

Solenoid
STAINLESS STEEL
Valves

LARGE IN CAPACITY



THREE WAY-Two Position-Normally Closed-Normally Open-Directional Flow
TWO WAY-Normally Closed **TWO WAY-Normally Open**

Skinner Solenoid Valves are extremely compact yet have unusual capacity—a great asset to designers looking for positive, accurate, long-lived controls for liquid and gaseous media. Available in standard pressure range of 5 to 250 p.s.i. and special from 5 to 850 p.s.i. Impregnated coils withstand moisture. Soft insert seats prevent leakage. Spring loaded for positive action. Usable in any position. Power consumption of 10 watts max. Pipe connections available to your specifications.

Write for Bulletin No. 491

SKINNER ELECTRIC VALVES

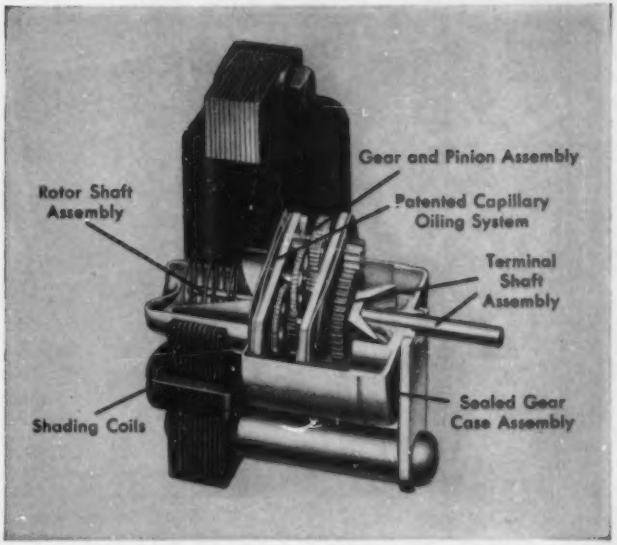
Skinner ELECTRIC VALVE DIV.
THE SKINNER CHUCK COMPANY
132 Belden Ave., Norwalk, Conn.

Floating Rotor Prevents Motor Lag or Slippage

Specially designed light-weight rotor virtually floats in a rotating magnetic field. Rotor shaft rotates on a film of oil . . . no metal to metal contact with its bearing. These features, together with capillary oiling system, account for the fact that *All Telechron Timing Motors Are Instantly, Constantly Synchronous.*

That is why so many designers concerned with split-second timing or control of light-weight moving parts specify Telechron motors.

If you have such a problem, why not turn it over to a Telechron Application Engineer? Drawing on the experience that makes all electric timing possible (virtually all frequency-controlling master clocks in power stations are made by Telechron), he can probably show you how a standard Telechron motor can do your job, too. Consult him early in your planning for big savings in time and money. Use handy coupon below for complete data. TELECHRON INC. A General Electric Affiliate.



Telechron Type B Synchronous Motor. For medium duty purposes such as switches, recording-controlling mechanisms and other control equipment. Other models with lower or higher torque for light or heavy duty applications.

Typical of Telechron Type H3 light duty motor applications is this 60-minute timer, the purpose of which is to operate a switch or signal at the end of a pre-selected period.

Practically all time-stamps and recorders employ Telechron Type B motors to operate their timing mechanisms. Obviously a motor that is instantly, constantly synchronous is needed for such applications.

Telechron®

ALL TELECHRON TIMING MOTORS ARE

INSTANTLY . . . CONSTANTLY SYNCHRONOUS

TELECHRON INC.
10 Union Street
Ashland, Massachusetts

Please send me information on sizes and types of Telechron Synchronous Motors. My possible application is:

Instruments	☐	Communications Equipment	☐
Timers	☐	Other (please fill in)	
Electric Appliances	☐	.....	
Cost Recorders	☐	.....	
Advertising, Display Items	☐	.....	
Juke Boxes	☐	.....	
Air Conditioning & Heating Controls	☐	.....	

☐ Please send new Catalog

NAME .....

COMPANY .....

ADDRESS .....

CITY ..... ZONE .....

STATE .....

The ABC of MST

Michigan

The Modern Electric Resistance

WELDED

STEEL

TUBING

ROUND

SQUARE-RECTANGULAR

Consult us for engineering and technical help in the selection of tubing best suited to your needs.

Thousands of products, from intricate automobile and truck parts to furniture and vacuum cleaners, are made better and more economically with MICHIGAN TUBING. We invite you to consider the many advantages of using it in the fabrication of YOUR product.

A Quality Product, can be worked in your plant or prefabricated by MICHIGAN.

Michigan STEEL TUBE PRODUCTS CO.

33 Years in the Business

9450 BUFFALO STREET • DETROIT 12, MICHIGAN

FACTORIES: DETROIT, MICHIGAN • SHELBY, OHIO

DISTRIBUTORS: Steel Sales Corp., Detroit, Chicago, St. Louis, Milwaukee, Indianapolis and Minneapolis—Miller Steel Co., Inc., Hillside, N. J.—C. L. Hyland, Dayton, Ohio—Duke & Company, Portland, Oregon—James J. Shannon, Milton, Mass.—Service Steel Co., Los Angeles, Calif.—American Tubular & Steel Products Co., Pittsburgh, Pa.—Strong, Carlisle & Hammond Co., Cleveland, Ohio

REMINDER:

to MOVERS!

Clip this ad and save it as a reminder to notify the Circulation Department at least a month in advance of any contemplated change in address. Taking care of the matter long before you actually move will assure you of uninterrupted service. When writing, be sure to include your name, old address — new address and about when you will move. Your cooperation will be appreciated!

PRODUCT ENGINEERING

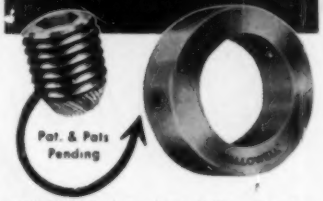
Circulation Department

330 West 42nd Street

New York 18, N. Y.

HALLOWELL

Steel Collars



HALLOWELL Solid Steel Collars, functionally proportioned throughout . . . precision-machined so faces run perfectly true . . . are beautifully polished all over . . . yet they cost less than common cast iron collars. 3" bore and smaller are made from Solid Bar Stock. To make sure the collar won't shift on the shaft, they are fitted with the famous UNBRAKO Knurled Point Self-Locking Socket Set Screw—the set screw that won't shake loose when once tightened. HALLOWELL . . . a "buy word" in shaft collars . . . available in a full range of sizes for IMMEDIATE DELIVERY.

Write for name and address of your nearest HALLOWELL and UNBRAKO Industrial Distributors.

OVER 47 YEARS IN BUSINESS

STANDARD PRESSED STEEL CO.

JENKINTOWN 28, PENNSYLVANIA

Chicago • Detroit • St. Louis • San Francisco

OHMITE

25th Anniversary

1925-1950

Contributing to

ONE-QUARTER CENTURY of PROGRESS

in the

ELECTRICAL CONTROL INDUSTRY

OHMITE MANUFACTURING COMPANY

Rheostats • Resistors • Tap Switches

Here's Why You Get

UNFAILING DEPENDABILITY with OHMITE RHEOSTATS

Years of field experience emphasize the underlying soundness of Ohmite rheostat design. These rheostats are constructed entirely of ceramic and metal—contain nothing to char, burn, shrink, or deteriorate. Ceramic parts insulate the shaft and mounting. The resistance winding is permanently locked in place by vitreous enamel. Every turn is contacted by the smoothly gliding metal-graphite brush, wearing smooth, gradual clean paths.

OHMITE MANUFACTURING CO.
4819 Flournoy St.
Chicago 44, Ill.

UNIFORM CONTACT PRESSURE
Spring steel contact arm forms a long spring which assures uniform contact pressure at all times.

UNIFORM SLIP-RING PRESSURE
Compression spring maintains uniform pressure and electrical contact between slip ring and center lead. Pressure here is independent of that at the contact brush.

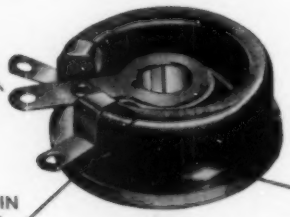
METAL-GRAPHITE BRUSH
Assures perfect contact with negligible wear on the wire.

SHAFT INSULATED FROM LIVE PARTS
High-strength ceramic hub insulates shaft and bushing from all live parts.

STOP PREVENTS STRAIN ON CONTACT ARM
Stop, keyed to the shaft, limits the rotation of the arm. No torsional strain is imposed on the arm in stopping.

THREE TERMINALS
Ohmite rheostats are provided with three terminals, so they can be used as potentiometers (voltage dividers), or to permit alternate rheostat connections.

WEAR-RESISTANT BEARING
Brass bushing for the steel shaft provides a wear-resistant, wobble-free bearing.



LOCKED-IN WINDING
Special alloy resistance wire is wound over a porcelain core. Each turn is firmly locked in vitreous enamel.

VITREOUS ENAMEL BOND
Vitreous enamel bonds the ceramic core and base together into one integral unit.

BEND-UP LOCK WASHER
Bend-up lock washer provides positive assurance against loosening of the assembly nut.

Write on Company Letterhead for Catalog and Engineering Manual 40.

Be Right with

OHMITE

RHEOSTATS • RESISTORS • TAP SWITCHES

25th Anniversary

QUALITY
ALL THE WAY THROUGH

WEIRITE — HOT-DIP AND ELECTROLYTIC TIN PLATE, TIN MILL BLACK PLATE AND SPECIAL COATED MANUFACTURING TERNES

WEIRZIN — ELECTROLYTIC ZINC-COATED SHEETS AND STRIP

WEIRTON — HIGH-CARBON STRIP
COLD-ROLLED SPRING STEEL

WEIRALEAD — LEAD ALLOY COATED SHEETS AND LONG TERNE SHEETS

WEIRCOLOY — GALVANIZED SHEETS

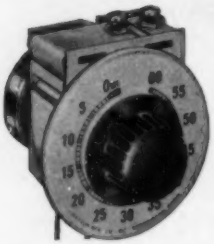
N-A-X — HIGH-TENSILE LOW-ALLOY STEELS

Lacquered and Coated Products • Tie Plates • Structurals • Bars • Piling
Hot-Rolled Sheets and Strip • Cold-Rolled Sheets and Strip • Angles

WEIRTON STEEL CO.
WEIRTON, W. VA. *Sales Offices in Principal Cities*
Division of NATIONAL STEEL CORPORATION *Executive Offices, Pittsburgh, Pa.*

Timing Ideas

A BEAR FOR PUNISHMENT



IF you're looking for a rugged, heavy duty interval timer, this Haydon® unit will save you time and money. It will meet every test for stamina, dependability and efficiency; is designed as a versatile, multi-purpose unit. Whatever your need for an interval timer may be, see the Haydon Series 8006 first.

CHECK THESE 8006 FEATURES

1. Standard models for intervals of 1, 15, 60 and 180 minutes; dial and knob optional. **2.** Other models for intervals up to 24 hours or more are available, without dial or knob. **3.** HOLD feature furnished if wanted. **4.** Heavy duty switch is rated 28A, 250 VAC; 1 HP 250 VAC. **5.** Heavy contact pressure; ample follow-through is assured. **6.** Snap action device gives quick, positive break. **7.** Removable dust cover for timer; totally enclosed motor. **8.** Settable in either direction, to start or when operating. **9.** May be used under conditions of high temperature and humidity.

ALL HAYDON TIMING DEVICES GIVE YOU

these advantages of the dependable Haydon Motor: Total enclosure — Very small size — Slow (450 rpm) rotor for long life, quiet operation — Controlled lubrication with separate systems for rotor and gear train — Mounting and operation in any position.

® TRADE MARK REG. U.S. PAT. OFF.

For complete design and engineering specifications, write for catalog: Timing Motors No. 322 — Timers No. 323 — Clock Movements No. 324. Yours without obligation.

HAYDON AT TORRINGTON

HEADQUARTERS FOR **TIMING**

HAYDON Manufacturing Co., Inc.

3126 ELM STREET

TORRINGTON, CONNECTICUT

SUBSIDIARY OF **GENERAL TIME** CORPORATION

How to organize, operate and control a product-design engineering department

Here is a book that will show you tested methods to facilitate production and reduce costs in your engineering department. Designed to minimize paperwork without sacrificing control, this book outlines the basic functions necessary to all successful engineering departments, large and small. These fundamentals are discussed in full to clearly point the way to smoother operation, higher production and greater economy in your organization.

ENGINEERING ORGANIZATION AND METHODS

by JAMES E. THOMPSON

Consulting Industrial Engineer; Formerly Chief Engineer, Booth Manufacturing Corporation; Administrative Engineer, The Ryan Aeronautical Company

337 Pages, 6 x 9, $4.00

McGraw-Hill Industrial Organization and Management Series

This practical guide analyzes each step of procedure used by successful engineering departments to handle prime functions and establish basic control. In its fifteen chapters you are led through a complete study of your problems relative to organization, personnel, cost control, drawings, part numbering, cataloging, print control and many other important subjects. It explains methods found superior in delegating authority, apportioning duties and avoiding overlapping between sections. Over 150 charts and diagrams assist you in clearly understanding the methods described. The information in this book applied to your organization will result in maximum efficiency and cost reduction.

15 Helpful Chapters:

1. Organization
2. Operation
3. Personnel
4. Cost Control
5. Planning
6. Standards
7. Drawing and Report Numbering
8. Drawing Forms and Title Blocks
9. Drawing Release
10. Drawing Print Control
11. Advance Engineering Information
12. Drawing Changes
13. Technical Services
14. General Services
15. Fundamentals of Engineering Management

10 Days FREE Examination—Mail Coupon

McGraw-Hill Book Co., 330 W. 42 St., NYC 18

Send me Thompson's ENGINEERING ORGANIZATION AND METHODS for 10 days' examination on approval. In 10 days I will send $4.00, plus a few cents postage, or return book postpaid. (Postage paid on cash orders.)

Name .....

Address .....

City and State .....

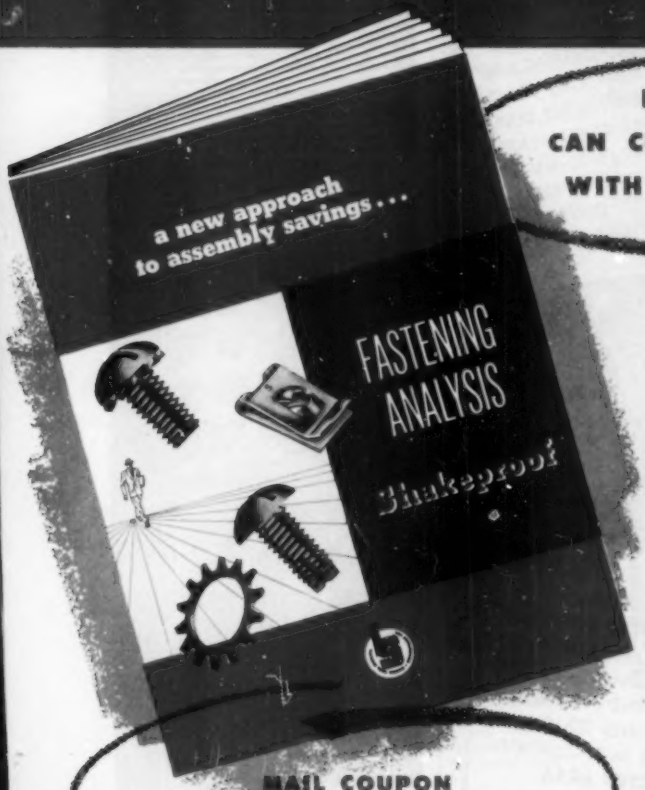
Company .....

Position ..... PPE 2-50

Books sent on approval in U. S. and Canada only.

to all designers

OF ASSEMBLED METAL PRODUCTS



LEARN HOW YOU CAN CUT PRODUCTION COSTS WITH BETTER FASTENINGS!

Important savings are certain . . . proved by America's leading manufacturers . . . no charge or obligation . . . Here, told for the first time, is a story of great importance to the design engineers of every company making assembled metal products . . . the story of Shakeproof's "Fastening Analysis" service. This twelve page booklet presents a real opportunity to achieve major savings in both time and money . . . plus the sales gains that are certain with improved product performance.

See how Shakeproof engineered fastenings are now saving hundreds of thousands of dollars every year for leading manufacturers in nearly every industry. Learn how the same principles can be applied to your assembly! Write for your free copy of "Fastening Analysis by Shakeproof" today!

MAIL COUPON FOR YOUR *FREE* COPY TODAY!

SEND MY FREE COPY OF "FASTENING ANALYSIS BY SHAKEPROOF"

NAME _____ TITLE _____

COMPANY _____

STREET AND NUMBER _____

CITY _____ ZONE _____ STATE _____

SHAKEPROOF inc.

DIVISION OF ILLINOIS TOOL WORKS

2501 North Keeler Avenue, Chicago 39, Illinois

In Canada: Canada Illinois Tools, Ltd., Toronto, Ontario

"FASTENING HEADQUARTERS"

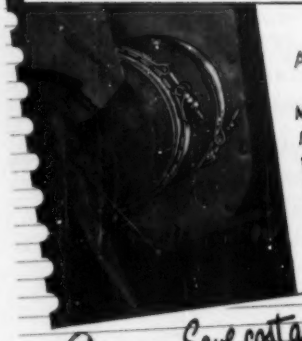
ENGINEERS NOTEBOOK

TO JOIN BEADED TUBES AND DUCTS

MARMAN CHANNEL-BAND COUPLINGS PROVIDE AN EFFECTIVE JOINT AND SEAL FOR ELBOW IN AIR DUCT. WILL ACCOMMODATE PRESSURES TO 400 P.S.I. DEPENDING ON DIAMETER AND TEMPERATURES FROM −100°F TO 500°F BY USE OF DIFFERENT SLEEVE LINERS

FOR EASY ASSEMBLY OF LOW PRESSURE AIR DUCTING

MARMAN UNIVERSAL (QUICK-DETACHING) CLAMPS SAVE TIME AND COST IN ALL SUCH APPLICATIONS. PHOTO SHOWS DUCT PRIOR TO CONNECTION OF MALE END. FABRIC COVERING PROVIDES SEAL WHEN CLAMP IS TIGHTENED



ATTACHMENT OF FLANGED HOT AIR EXHAUST

MARMAN VENTILATED COUPLING MAKES AN IDEAL ATTACHMENT FOR METAL BELLOWS BETWEEN HOT AIR DUCT AND HEATER. FLEXIBILITY OF THIS COUPLING PROVIDES EASY INSTALLATION IN RESTRICTED AREA

Save cost and design time with Marman

FOR INFORMATION WRITE DEPT. E-2

THE BEST CLAMPS, STRAPS AND COUPLINGS

MARMAN PRODUCTS CO. INC.

940 W. FLORENCE AVENUE
INGLEWOOD, CALIFORNIA

3

LITTLEFORD WELDMENTS

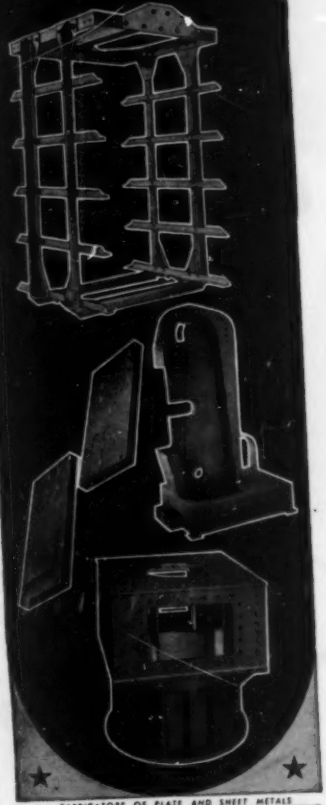
for

Production Economy

Littleford facilities and skilled workmen are qualified to fabricate any product of plate or sheet metal that may apply to your production.

Littleford weldments have long been known for uniformity, accuracy, strength and adaptability. Rigid demands of manufacturing plants, design engineers, have been met easily and without exception.

If you have a weldment problem send blueprints to Littleford, see how experience can insure economies in plate and sheet metal fabrication.



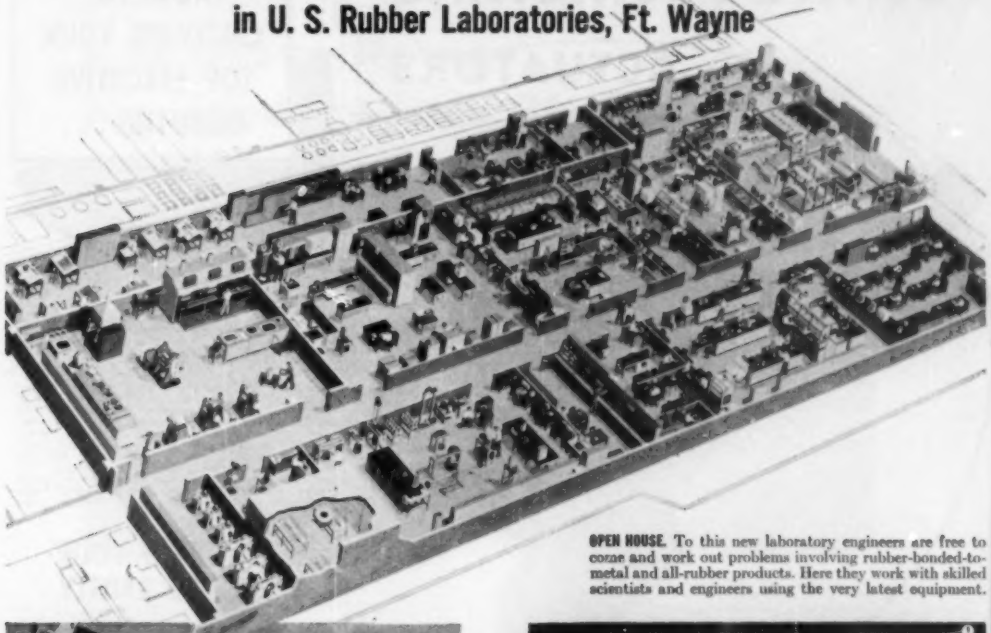
FABRICATORS OF PLATE AND SHEET METALS

LITTLEFORD

LITTLEFORD BROS., INC.
508 E. Pearl St., Cincinnati 2, Ohio

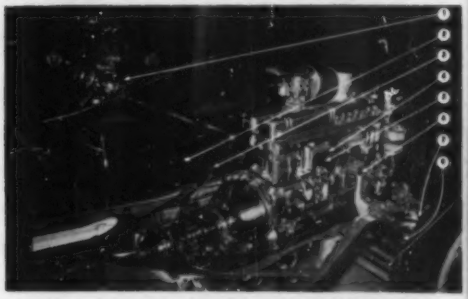
TREASURE HOUSE OF SCIENCE

Harmful vibration and noise in mechanical equipment eliminated in U. S. Rubber Laboratories, Ft. Wayne



OPEN HOUSE. To this new laboratory engineers are free to come and work out problems involving rubber-bonded-to-metal and all-rubber products. Here they work with skilled scientists and engineers using the very latest equipment.

ONE WAY IT PAYS OFF . . . a new "U. S." rubber Evener Bearing Assembly developed jointly at Ft. Wayne for this oil well pumping unit. Its simplified design eliminates 62 parts. Maximum shock protection allows 200% longer wear.



HERE'S ANOTHER . . . just 8 of 350 automotive applications for rubber parts developed in the Ft. Wayne Laboratory: 1) steering wheel. 2) brake lever pedal pad. 3) brake lever seal. 4) ignition wire. 5) ignition wire ferrules. 6) front engine mounting. 7) control arm rebound bumper. 8) spring bumper.

Are you concerned with reducing noise, vibration, shock in mechanical equipment . . . with reducing strain on individual metal parts? If so, U. S. Rubber Engineers invite you to work out your problems with them in their Ft. Wayne Laboratory —control center for the world's most modern Engineered Rubber Products Plant. Send for your copy of the new informative booklet, "This Is Your Laboratory." Write to Engineered Rubber Products Division,

A DEVELOPMENT OF

U.S.RUBBER
SERVING THROUGH SCIENCE

UNITED STATES RUBBER COMPANY

ROCKEFELLER CENTER, NEW YORK 20, N. Y.

AIR ASSOCIATES

POSITIVE POSITIONING ACTUATORS

Positive positioning control is assured in Air Associates actuators by using internal load-limiting switches. The back-pressure exerted adjusts the actuators automatically. This counteracts backlash and eliminates surface flutter as well as switch adjustments at installation and in service. Air Associates non-jamming actuators meet, or exceed, applicable AN specifications.

Air Associates designs and manufactures *electronic, hydraulic, electro-mechanical, pneumatic and miscellaneous* devices.

Also, twenty-two years' experience supplying the needs of manufacturers, airlines and airport operators has established Air Associates as the leading distributor of aircraft supplies.

Write For ENGINEERING CATALOG

AIR ASSOCIATES
INCORPORATED
Teterboro, New Jersey

DALLAS, TEXAS • CHICAGO, ILLINOIS • GLENDALE, CALIF.
EXPORT DEPARTMENT • CABLE ADDRESS 'AIRSOC,TETERBORO'

Serving the Nation in Aviation

What makes one man worth $40,000 — another only $4,000? . . . this book tells . . .

HOW TO CULTIVATE YOUR TOP EXECUTIVE QUALITIES . . .

—and win success faster in the upper brackets

TOP EXECUTIVES aren't born. They're made. Self-made mostly. Though they rise along different routes, the steps to their success are similar. They follow a definite course of action . . . and arrive at the top as planned. Now, here is a practical, inspiring book which brings you this amazing success formula. It outlines a specific, detailed plan for cultivating the qualities which mark the top-flight business leader today—illuminating each point with intimate, on-the-job studies of currently outstanding executives.

DEVELOPING YOUR EXECUTIVE ABILITY

By **Howard Smith**, Personnel Consultant, Noted Lecturer, and Instructor with Dale Carnegie Institute. 285 pages 5½ x 8, $3.00.

This book provides a blueprint that shows how you can win executive success. Showing that executive genius is not a quality one is born with, but the result of concentrated effort along the right lines, the book tells how to direct the same efforts and thinking which you already expend daily toward the definite goal of improving your executive ability. Packed with helpful pointers it tells how the up-and-coming executive can make the most of his capabilities, grow in executive stature, and rapidly qualify for the upper bracket responsibilities and rewards.

Some facts this book gives you:

- how to plan advancement
- the secret of executive personality
- 3 best methods for improving personality
- 11 ways to put over your personality
- 24 guideposts to productive thinking
- 11 aids for making decisions
- 11 steps for handling worries
- how to budget time most efficiently
- 12 tested techniques for giving instructions
- how to talk to groups effectively
- how to handle responsibility
- how to give yourself publicity

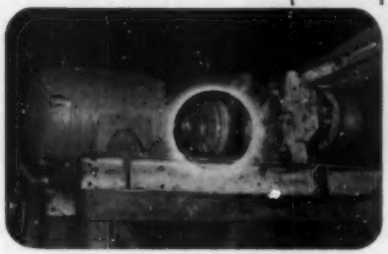
SEE THIS BOOK TEN DAYS FREE—MAIL COUPON

McGraw-Hill Book Co., 330 W. 42 St., N.Y.C. 18
Send me Smith's Developing Your Executive Ability for 10 days' examination on approval. In 10 days I will send $3.00, plus few cents for delivery, or return book. (We pay for delivery if you remit with this coupon; same return privilege.)

Name .....
Address .....
City and State .....
Company .....
Position .....
Books sent on approval in U. S. and Canada only.

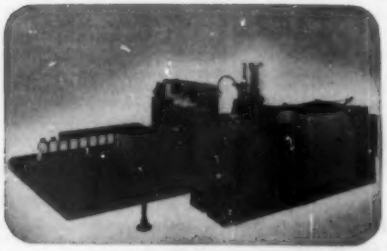
Kid Glove Power for product handling

Are you planning a conveyor or packaging machine that requires extra-smooth, steady power delivery . . . one that can't tolerate a "sticky" clutch with a jerky pace? Then it will pay you to check the following reports of Twin Disc shock-absorbing power links at work.



The Twin Disc Hydraulic Coupling* on this 500-foot coal mine conveyor cushions jolts of intermittent loading, starting and stopping . . . eliminates overmotoring at the start, prevents stalling of motor. *Ask for Bulletin 136.

To synchronize the two motors and prevent chain breaks on this pickling bin conveyor, a Twin Disc Hydro-Shaave Drive* was installed on each motor. The result was automatic synchronization of the motors, smoother operation, and a sharp reduction in maintenance costs and down-time. *Write for Bulletin 145-A.



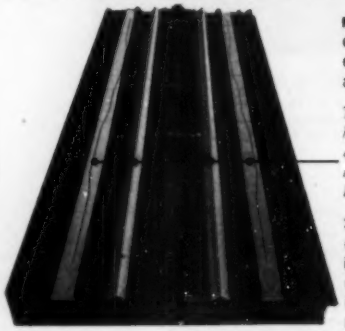
This Redington cartoning machine, continuously on the job since 1944, drives smoothly, quietly and efficiently through a Twin Disc Model MTS Friction Clutch.* Unusually compact, this clutch has exceptionally high torque capacity and is engineered to fit easily into your design. *Request Bulletin 134-A.

Twin Disc engineers, specialists in power transmission, have helped many of the country's leading manufacturers solve their application problems. They will gladly consult with you . . . at no obligation, of course.

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division, Rockford, Illinois).

SPECIALISTS IN INDUSTRIAL CLUTCHES SINCE 1918

50 tons on Formica bearing surfaces!



REDUCE WEAR . . . get lasting accuracy! It's being done today with Formica bearing surfaces. Leading examples are the G. A. Gray Company's planers and planer-type machine tools.

Take the case of the Gray 8" planer-type horizontal boring, drilling and milling machine. Its table is supported on two vee and two flat Formica bearing ways and will carry loads up to 180,000 pounds.

Such use of Formica end-grain bearing material eliminates the scoring and cutting common to cast iron. Properly lubricated, it reduces friction to a negligible factor. Finally, Formica's heat-insulating property guards against distortion and resultant loss of accuracy.

LET OUR ENGINEERS SHOW YOU how replacing metal with Formica pays dividends in any bearing surface application. Write today for detailed information. FORMICA, 4676 Spring Grove Ave., Cincinnati 32, Ohio.

Formica end-grain material is molded with laminations perpendicular to bearing surface. It permits higher bearing loads than cast iron and wears better.

"DATA FOR INDUSTRY"— Handy 96-page reference book on all grades of Formica—is yours, postpaid, for $1.00. Send for your copy!

A handy reference on formulas for...

- **STRESS**
- **STRAIN**
- **STRENGTH**

of materials

HERE'S your ideal guidebook on strength of materials. It contains extensive tables of formulas and numerous illustrative examples . . . includes the results of intensive analytical and experimental work . . . presents for your quick reference all the formulas for stress, strain, and strength useful to the design-engineer. It also brings you—*step-by-step*—the essential principles used in stress analysis, and provides you with fundamental data on the mechanical properties of materials.

Formulas for Stress and Strain

By RAYMOND J. ROARK

Professor of Mechanics, University of Wisconsin

366 pages, 6 x 9, 43 illustrations

SECOND EDITION, $4.50

PRODUCT DEVELOPMENT SERIES

This practical book takes you from basic definitions through clear statements of general principles, and right on to facts, figures and formulas for the calculation of stress and deflection. You get everything from the principles of superposition and least work to formulas for elastic stability of plates and shells.

Check the partial list of tables this guide puts at your fingertips:

- **—for straight beams, circular rings and flat plates under a wide variety of conditions of loading and support**
- **—for curved beams and torsion members of various sections**
- **—for thin- and thick-walled pressure vessels**
- **—for rollers and other bodies under direct pressure**
- **—for columns**
- **—for slender bars and thin plates in which failure occurs through elastic instability.**

SEE IT 10 DAYS—FREE

McGraw-Hill Book Co., Inc., 330 W 42nd St., N. Y. 18

Send me Roark's FORMULAS FOR STRESS AND STRAIN for 10 days' examination on approval. In 10 days I will remit $4.50, plus a few cents for delivery, or return the book. We pay for delivery if you remit with this coupon; same return privilege.

Name .....

Address .....

City ..... Zone.... State.....

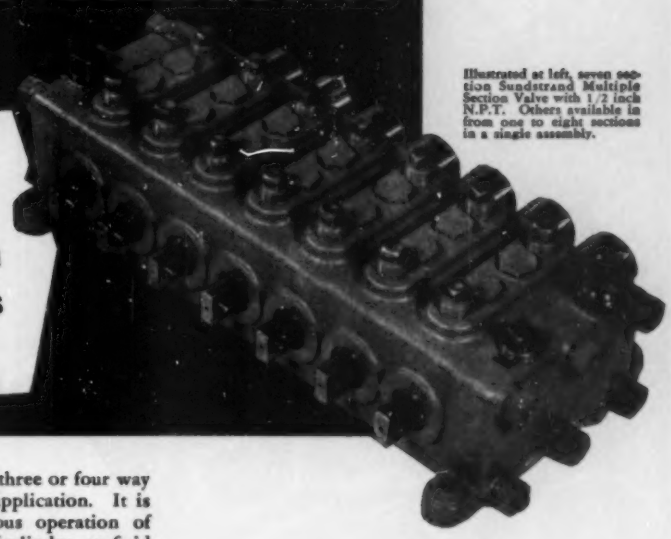
Company .....

Position PYE-2-50

Books sent on approval in U. S. and Canada only

When You Need Positive Control...

Use This New SUNDSTRAND Multiple Section Valve For Series Application



Illustrated at left, seven section Sundstrand Multiple Section Valve with 1/2 inch N.P.T. Others available in from one to eight sections in a single assembly.

Illustrated is a new Sundstrand three or four way Multiple Section Valve for series application. It is manually controlled for simultaneous operation of more than one actuated member (cylinder or fluid motor) from a single oil power source or pump, provided the total accumulated load on all actuated members does not exceed the relief valve setting.

These valves are made up of individual sections for control of each actuated member and may be furnished in up to eight controls in a single assembly. Sundstrand Multiple Section Valves are compact and can be conveniently placed for control of moving members from one station. They are made up of heavy close grained cast iron body sections and have ample mounting lugs. The stem for each section is sealed against oil leakage as well as infiltration of dirt or foreign material that might impair operation.

Has Built-In Relief and Check Valve

Overload control is provided by a built-in adjustable relief valve. In addition, two check valves in each section maintain positive positioning of actuated member and prevents losing control of the load.

Uses for Sundstrand Multiple Section Series Valves

Simple oil power hydraulic control can be easily applied to equipment such as dredging equipment, road machinery, excavating machines, snow removal machines, farm tractors, industrial tractors, well digging equipment and similar types of machinery.

Get Complete Data

This engineering data sheet provides complete dimensions, mounting information and capacities. Write for your copy today. Ask for bulletin No. P-50.

SUNDSTRAND MACHINE TOOL CO. ROCKFORD ILLINOIS U.S.A.

SUNDSTRAND HYDRAULIC DIVISION

2560 ELEVENTH STREET • ROCKFORD, ILLINOIS

FUEL UNITS • HYDRAULIC PUMPS • TRANSMISSIONS • FLUID MOTORS • VALVES and CONTROLS

that pot of gold is yours

WITH

MicroRold Stainless Steel Sheet and Strip

IF you want stainless steel having

- ★ More area per ton

or

- ★ Equivalent area weighing 3% to 8% less

or

- ★ Unusually high physical properties

or

- ★ Reduced polishing costs

AND

IF you are interested in savings in cost of $152.00 per 100 sheets of polished 18 gauge _____

use this coupon today

WASHINGTON STEEL CORPORATION
122 WOODLAND AVENUE
WASHINGTON, PENNSYLVANIA

Please tell me more about

☐ MicroRold's savings in fabricating

☐ Savings in material costs

Name.....

Company.....

Address.....

City.....State.....

WASHINGTON STEEL CORPORATION
122 WOODLAND AVENUE
WASHINGTON, PENNSYLVANIA

Bringing together for the first time . .

Engineering data on the design of ultrasonic systems

Considers the many uses of ultrasonics in industry

HERE is the first engineering consideration of the ultrasonic field . . . the essential theory, plus an abundance of practical information never before published! This important new book reviews electronic considerations and outlines of circuits. Mechanical and electrical design and construction techniques of ultrasonic systems are included . . . everything from the design considerations of holders for ultrasonic use to the experimental measurement of ultrasonic waves in various media.

Just Published!

ULTRASONICS

By Benson Carlin

Formerly, Product Research Supervisor, Sperry Products

264 pages • 162 illustrations • $5.00

BOTH theoretical and practical, this book is definitely slanted toward engineering design and use in definite industrial applications. It brings you valuable information on: material testing, agitation, ultrasonic transducers, ultrasonic systems. It explains clearly the characteristics of ultrasonic waves that are important in practical applications: curves, waves, and complex waves; Fourier's theorem, wave trains and the law of angular transmission; the ways ultrasonic waves may be produced, and the electro-mechanical converting systems.

Evaluates Practical Uses in Many Fields

Brought out of the research laboratory and into industry, ultrasonics has tremendously broad, practical applications. This guide points the way to greater use of ultrasonics in, for example, MATERIALS TESTING: to detect flaws in metals, plastics and glass, etc.; CHEMICAL INDUSTRIES; to make better mixtures and emulsions, etc.; METALLURGY: for extremely uniform mixtures free of air bubbles, etc. It likewise discusses experimental applications to systems of television, underwater signaling, depth sounding, communication, destruction of bacteria, etc.

CONTENTS

1. Ultrasonic Waves
2. Ultrasonic Waves: Further Theory
3. Crystals for Ultrasonic Use
4. Crystal Holders for Ultrasonic Use
5. Resonance and Reflection
6. Continuous-wave Ultrasonic Systems
7. Pulsed Ultrasonic Systems
8. Ultrasonic Agitation
9. Magnetostriction
10. Practical Considerations in the Application of Ultrasonics

SEND NO MONEY

SEE IT 10 DAYS FREE

McGraw-Hill Book Co.
330 W. 42d St., NYC 18

Send me Carlin's ULTRASONICS for 10 days' examination on approval. In 10 days I will send $5.00, plus a few cents delivery charge, or return the book postpaid.*

Name .....

Address .....

City .....Zone.....State.....

Company .....

Position PPE-2-50

*SAVE! We pay mailing costs if you send cash with this coupon. Same return privilege.

The world's largest plant devoted to the design and production of molded carbon-graphite-powdered metal specialties.

Rare Metal Contacts
Brushes and Contacts
(all carbon, graphite, metal and composition types)
Anodes • Electrodes
Bearings
Welding and Brazing Products
Carbon Pipe
Chemical Carbons
Power Tube Anodes
Sintered Alnico II
Flashlight Battery Carbons
Packing, Piston and Seal Rings
Rheostat Plates and Discs, etc.
Stackpole Electronic Products
Fixed and Variable Resistors
Iron Cores
Switches—Line and Slide types to 3 amps.

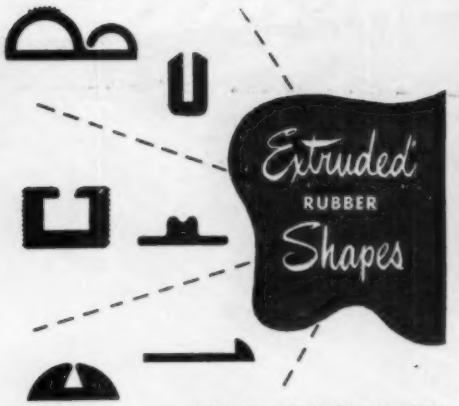
CARBONS, GRAPHITES AND MOLDED METAL COMPOSITIONS

Here you see just a few of thousands of molded carbon, graphite, powdered metal and composition components manufactured by Stackpole. What you *don't* see is the tremendous background of engineering experience that goes into their production. And *that* makes a difference! It eliminates guesswork. It means that each particular product is made to conform EXACTLY to its own specific operating conditions. It means longer, more dependable service.

We can't sell our experience . . . you get that free. Yet it's the most valuable part of every Stackpole product you buy!

STACKPOLE CARBON CO., ST. MARYS, PENNA.

STACKPOLE



WHAT DO YOU NEED?

We have a multitude of dies available to meet your requirements. Designs shown are but a few in our large and varied assortment. Lowest possible cost per unit. Send specifications *today.*

FREE: 44 page catalog

Illustrates and describes complete LAVELLE line mechanical and industrial rubber specialties. Request your copy today.

Take It Up With

LAVELLE *Rubber Company*

1801 WEST HUBBARD STREET, CHICAGO 22, ILLINOIS

LARGEST, MOST VARIED STOCK IN U.S.A.

Every shape and size to meet your demand. Lowest possible cost per unit. Prompt shipment. Write, wire, or telephone your specifications, *today.*

FREE! NEW 44 PAGE CATALOG

Full data on all Mechanical and Industrial Rubber Goods. 36 years experience. Request Catalog MS-46 *today.*

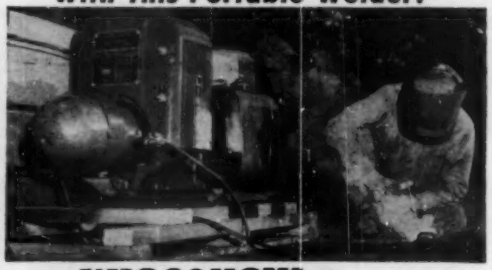
Take it up with

LAVELLE *Rubber Company*

1801 WEST HUBBARD STREET, CHICAGO 22, ILLINOIS

FAST ON-THE-SPOT REPAIRS

With This Portable Welder!



It's* WISCONSIN *Powered!

Welding at the breakdown-scene . . . adds up to savings in time and labor with this light but rugged 180 amp. Lincoln Welder, made by Lincoln Electric Co., Cleveland, Ohio, powered by a two-cylinder Wisconsin Heavy-Duty Air-Cooled Engine.

The performance satisfaction of Wisconsin Engine power increases not only the reliability of equipment in all fields, but also increases the confidence of both equipment user and builder. They're sold on such features as self-cleaning, thrust-absorbing Timken tapered roller bearings at both ends of the crankshaft . . . fool-proof air-cooling, from sub-zero to 140°F . . . an easily serviced OUTSIDE rotary type, high tension magneto with impulse coupling, for quickest any-weather starts . . . plus heavy-duty construction, inside and out.

Your investigation is invited! 3 to 30 hp., 4-cycle single-cylinder, 2-cylinder, and V-type 4-cylinder models.

WISCONSIN MOTOR CORPORATION

World's Largest Builders of Heavy-Duty Air-Cooled Engines

VULCAN

TERMINALS AT EACH END

TERMINALS AT ONE END

FLAT HEATING UNITS

HIGHER WATTAGE PER SQUARE INCH BECAUSE OF CERAMIC INSULATION

1. Seamless
2. Single or Three-heat
3. Standard widths—¾", 1", 1½", 1¾"
4. Practically any length up to 120"
5. With or without mounting holes
6. Can be formed into Band Heaters—one piece or hinged

If you have a problem involving electric heaters—flat, cartridge, immersion, tubular or special—write us. We like problems.

VULCAN ELECTRIC COMPANY

DANVERS 18, MASS.

Makers of Vulcan Electric Soldering Tools, Electric Solder Pots, Electric Glue Pots, Electric Branding Irons and Electric Heating Units, including the new Vulcan 900 series for changing over any hot water heater to electric operation.

NEVER TOO MUCH... NEVER TOO LITTLE
BUT **ALWAYS** JUST RIGHT

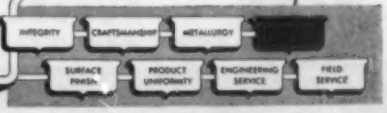
because of
TOLERANCE CONTROL

Another reason why industry prefers SKF

Remember leapfrog? How you used to have to skim over just right? Well, it's very much the same thing in specifying bearings. You don't want tolerances too great... and you don't want tolerances closer than the job demands. But you want to be sure that tolerances are *right*... are *always* properly controlled... *always* meet established standards. SKF adheres rigidly to these standards. Ceaseless vigilance in every stage of production assures complete control of tolerance throughout the entire manufacturing cycle. You can always be sure that any SKF Bearing will exactly meet your requirements... and will meet them again and again. Never forget, either, that *tolerance control* is only *one* reason why SKF Bearings will help you build equipment which, through smooth, economical performance, helps develop greater acceptance for your product. SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

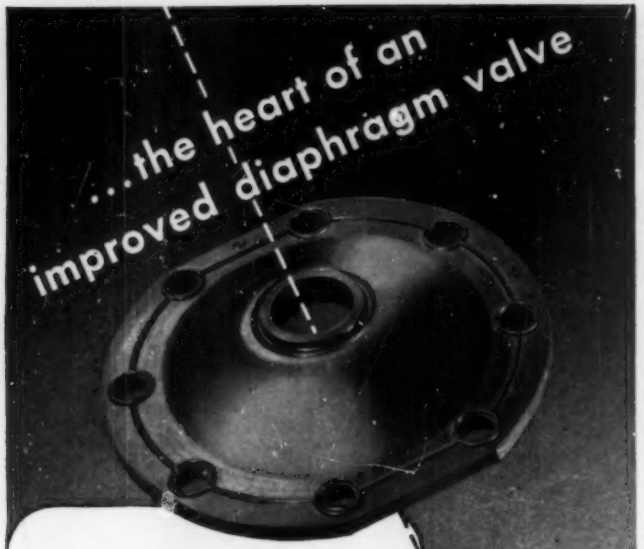
SKF
Ball and Roller Bearings

8 REASONS WHY SKF IS PREFERRED BY ALL INDUSTRY



Inventors and Pioneers of the Self-Aligning Ball Bearing and Spherical Roller Bearing

7050

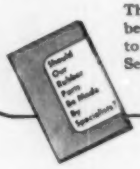


This rubber diaphragm is a vital part of an improved "packless" valve recently developed by a leading valve manufacturer. It provides an air-tight seal against any leakage of gases or volatile, hard-to-hold, corrosive fluids. The diaphragm is strong enough to withstand high pressures and yet sufficiently flexible for easy opening and closing.

Manufacturing specifications are exacting. In addition to heat, chemical, and abrasion resistance, the rubber diaphragms must endure test flexings equivalent to many years of normal operation.

Continental met—and exceeded—the required standards. To pre-test the diaphragms before delivery, Continental designed and built a special flexing machine. The successful solution of this problem is typical of the "technical service in rubber" offered by Continental.

When *you* need better engineered rubber parts, why not enlist the assistance of specialists?



This case history booklet has been a helpful "thought starter" to many users of rubber products. Send for your copy *today*.

CONTINENTAL
RUBBER WORKS
1984 LIBERTY BOULEVARD • ERIE, PENNSYLVANIA

BRANCHES

Baltimore, Md.	Dayton, Ohio	Luth, Fla.	Rochester, N. Y.
Boston, Mass.	Detroit, Mich.	Memphis, Tenn.	St. Louis, Mo.
Buffalo, N. Y.	Hartford, Conn.	Milwaukee, Wis.	San Francisco, Calif.
Chicago, Ill.	Indianapolis, Ind.	New York, N. Y.	Syracuse, N. Y.
Cincinnati, Ohio	Kansas City, Mo.	Philadelphia, Pa.	Wilmington, N. C.
Cleveland, Ohio	Los Angeles, Calif.	Pittsburgh, Pa.	

PLASTICS *as* ENGINEERING MATERIALS

This PRODUCT ENGINEERING reprint offers valuable data on plastics as attractive engineering materials. It discusses the advantages plastics offer in weight savings, lower costs, moisture and chemical resistance, toughness and abrasion resistance, and many other qualities that are the everyday concern of any design engineer specifying plastics in his products.

This informative report covers the functional use of plastics in the following applications:

- Heavy duty electrical equipment
- Heavy production machinery
- Motor parts
- Bearings and gears
- Home appliances
- Hydraulic components
- Photographic equipment
- Automobiles

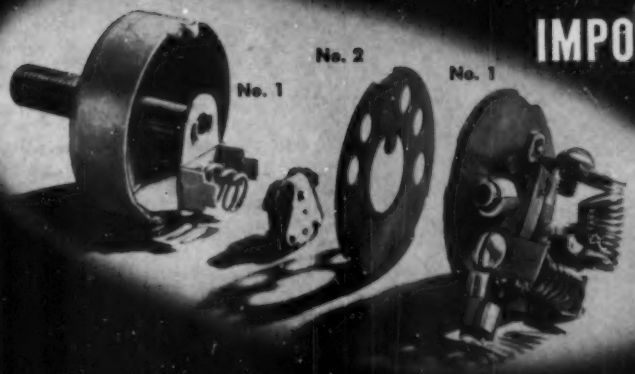
Reprints in 24-page booklet form are available at 25¢ each from the Reader Service Department.

•

PRODUCT ENGINEERING
330 W. 42ND STREET
NEW YORK 18, N. Y.

LAMINATED INSUROK BY RICHARDSON . . .

DOES 3 IMPORTANT JOBS



. . . on a five way switch for Nash

In making a five way switch for the famous Nash Weather Eye Conditioned Air System, the Douglas Manufacturing Division, Bronson, Mich., needed three parts made of plastic insulation material that embodied a variety of characteristics. Richardson's Laminated INSUROK, in two different grades, was the answer.

One paper-base grade of Laminated INSUROK met all requirements for two of the parts because of its low moisture absorption, high strength, rigidity, dielectric strength, ease of fabrication and low cost. Another grade, with a fabric base, met special requirements for physical strength for the third part.

Two grades of INSUROK, in combination with metal components, resulted in a five way switch that will operate smoothly over long years of trouble-free use.

Perhaps Richardson's diverse materials of either Molded or Laminated plastic, standard or special, can solve a manufacturing problem for you.

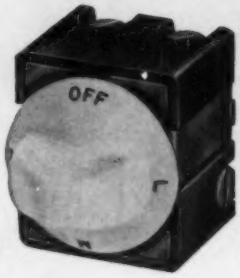
INSUROK by RICHARDSON
Dependable names in plastics
INSUROK - Registered Trade Mark

The RICHARDSON COMPANY
GENERAL OFFICES: LOCKLAND, OHIO FOUNDED IN 1858
Sales Headquarters: MELROSE PARK, ILLINOIS
2793 LAKE STREET

CLEVELAND • DETROIT • INDIANAPOLIS • MILWAUKEE • NEW BRUNSWICK, (N.J.) • NEW YORK • PHILADELPHIA • ROCHESTER • ST. LOUIS

Completely New!

An Entire Series of NEW, SMALL ROTARY SWITCHES By "Diamond H"



Series 240 Switches
Single Hole Mounting
Model Shown actual size
1½" high x 1¼" wide x 1" deep
AND Attractive Bezel-equipped Models for snap-in mounting.

Both Types Available In These Circuits:
Series Parallel 3 heat 4 position, Double Pole
Series Parallel 3 heat 4 position, Single Pole
ON & OFF, both Double Pole and Single Pole
OFF-ON (circuit 1) — OFF-ON (circuits 1 & 2) Double Pole
15 A., 125 V., 7½ A., 250 V. A.C. Only
Underwriters' Laboratories Approved

For BIG Jobs In Applications Like These . . .

Hot Plates Rangettes Coffee Makers
Fan-type Heaters Beauty Parlor Equipment
Air Conditioning Equipment Fans Washers
Ventilating Equipment Small Motors
And similar appliances and equipment

NO OTHER SWITCH WILL GIVE YOU ALL THESE LONG-WANTED FEATURES

- *COMPACTNESS* — unmatched by any other switch.
- *HEAT RESISTANCE* — completely efficient operation with ambient temperatures up to 400° F.
- *ENTIRELY ENCLOSED* — for safety's sake and protection of working parts.
- *HIGH OVERLOAD CAPACITY* — ratings are conservative.
- *PROVEN PEAK PERFORMANCE* — thanks to long recognized "Diamond H" slow-break principle and heavy silver contacts.
- *LONG SERVICE LIFE* — because of ingeniously simple design and rugged construction.

Write today for complete details on "Diamond H" Series 240 Switches for your applications.

THE HART MANUFACTURING CO.
206 Bartholomew Ave., Hartford, Conn.

An-cor-lox gives *FULL* locking security

1. When nut is pulled up, metal locking ring flows into bolt threads, wedging the lock nut threads into a positive lock.
2. Once flattened by use, the non-springing locking ring stays deformed, even after backing off. Grip is increased by re-use.
3. Vibration and shock will not walk bolt off—they serve only to force the locking ring farther into the threads.
4. Bolt stretch, wear and moisture do not affect the lock.
5. Up to softening point of the metal, high temperatures do not lessen gripping power.
6. Crushed locking ring prevents passage of gas or liquids.

Available in high, thin, cap or spanner designs

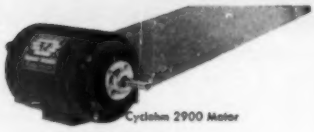
Note wedging action of flattened metal ring

Send for test samples and catalog

An-cor-lox TRADE MARK REGISTERED *Lock Nuts*

LAMINATED SHIM CO., Inc., *An-cor-lox Division*, 1402 Union St., Glenbrook, Conn.

AN-COR-LOX NUTS • SHIMS • SHIM STOCK • STAMPINGS


Cyclohm 2900 Motor

adaptability...

FRACTIONAL H. P. MOTORS
BY EMC AND *Cyclohm*

The Cyclohm 2900 Motor—Long Life • Minimum Vibration
Quiet Operation • Minimum Maintenance

There are a lot of good motors on the market... but you won't find a better motor than the Cyclohm 2900 at any price.

Cyclohm 2900 Motors can be supplied as Standard Capacitor Motors, Synchronous Hysteresis Motors, 2 Speed Capacitor Motors, Split Phase Motors or Brush Type (wound rotor) with or without gear reduction units. They are easily adaptable to your particular power problems, and as for applications, just check this list...

For laboratory equipment, vending machines, tape pulling, sound cameras, telegraph-terminal equipment, recording and facsimile equipment, take-up reels, reversing service and general service requiring a high quality motor.

These are motors worth knowing about, and so are the dozens of other motors made by EMC and Cyclohm. If your product needs fractional h.p., write today for handy reference literature and specification sheets. Two to one, you'll find the *right* motor at the *right* price.

HOWARD **HOWARD INDUSTRIES, INC.**
DEPT. PEA, RACINE, WIS.
DIVISIONS: ELECTRIC MOTOR CORP.
CYCLOHM MOTOR CORP.

Are you painting aluminum?

BONDERITE assures good paint performance on all aluminum alloys

Controls Corrosion too!

There's nothing so disappointing to maker and buyer alike as poor paint performance on a fine aluminum surface. It's totally unnecessary, too, for there's a simple treatment—Bonderite—that anchors paint tightly to aluminum, preserving fine appearance.

Paint on Bonderite-treated aluminum sheets or castings will not peel, chip, or crack. The millions of tiny phosphate Bonderite crystals, nonmetallic and integral with the metal, provide effective protection against corrosion and oxidation, too.

Bonderite for aluminum is simple, economical, easy to operate, fast, and uniform in results. The same Bonderite line that treats aluminum may be used to protect and prepare zinc and steel parts for painting.

Get lasting fine appearance for your painted aluminum production. Get the facts on Bonderite now!

PROTECTED BY Bonderite PARKER RUST PROOF CO. QUALITY CORROSION RESISTANT

Bonderite, Parco, Parco Lubrite—Reg. U.S. Pat. Off.

PARKER

PARKER RUST PROOF COMPANY
2179 East Milwaukee Ave.
Detroit 11, Michigan

BONDERITE—Corrosion Resistant Paint Base • PARCO COMPOUND—Rust Resistant • PARCO LUBRITE—Wear Resistant for Friction Surfaces

To Cut Production Costs . . .
"START WITH THE FINISH"

Unretouched photo reflects model measuring Wallingford Steel's new, wider 18-8 Bright Annealed Stainless. To 15" wide — to .070 gage.

WALLINGFORD 18-8 *Bright Annealed* STAINLESS STRIP

Metal fabricators interested in cutting costs and improving their products will welcome Wallingford Steel's 18-8 Bright Annealed Stainless. The bright, mirror-like surface of this corrosion-resistant stainless makes it possible to "Start With The Finish". Costly, intermediate steps in rough and finish grinding are cut to a minimum — completely eliminated in some cases! And the long-lived brilliance of Wallingford's 18-8 Bright Annealed means added sales appeal for your products — attracts the eye, then says, *"buy"*.

FREE SAMPLE and data sheet on request.

Write: 602 Valley Street, Wallingford, Connecticut.

THE WALLINGFORD STEEL CO.

SINCE 1922

WALLINGFORD, CONNECTICUT, U.S.A.

LOW CARBON • HIGH CARBON
ALLOY • STAINLESS • STRIP and TUBING

RECENT BOOKS
for the
Product Engineer
See them,
10 days FREE

PROCESS ENGINEERING

By William H. Schutt
Wm. H. Schutt Associates, Detroit

1. This book shows you how to establish the proper sequence of operations and exact labor cost *directly from the blueprint* . . . how to determine the quantity and cost of materials to be used . . . how to plan efficient tools, dies, jigs, and fixtures for economical production. Here's a money-saving book that eliminates guesswork in cost-estimating.

308 pages, $4.00

MACHINE DESIGN

By Paul H. Black
Prof. of Machine Design, Cornell University

2. Here is a complete discussion of each phase of machine designing, from the adaptability and selection of materials for the various machining processes to the elimination of vibration . . . practical aids, hints and suggestions on everything from good form in making machine-design computations to detachable machine fastenings.

Includes Full Treatment of Stress Concentration

Making the book unique is the complete treatment it gives to stress concentration—its applicability—seriousness—mitigation—determination—and design application.

334 pages $4.00

Engineering Applications of
FLUID MECHANICS

By J. C. Hunsaker,
Dept. of Aeronautical Eng., M.I.T.
and B. G. Rightmire,
Dept. of Mech. Eng., M.I.T.

3. Here is an unusually detailed book applying the important basic principles of fluid mechanics to everyday problems. It makes use of advanced, improved methods to analyze problems and equipment involved in fluid flow . . . covers hydraulic circuits and servomechanisms. Here are diagrams, formulas and equations necessary for a complete understanding of fluid mechanics . . . presented in easy-to-follow form for a quick understanding of the principles involved.

487 pages $5.00

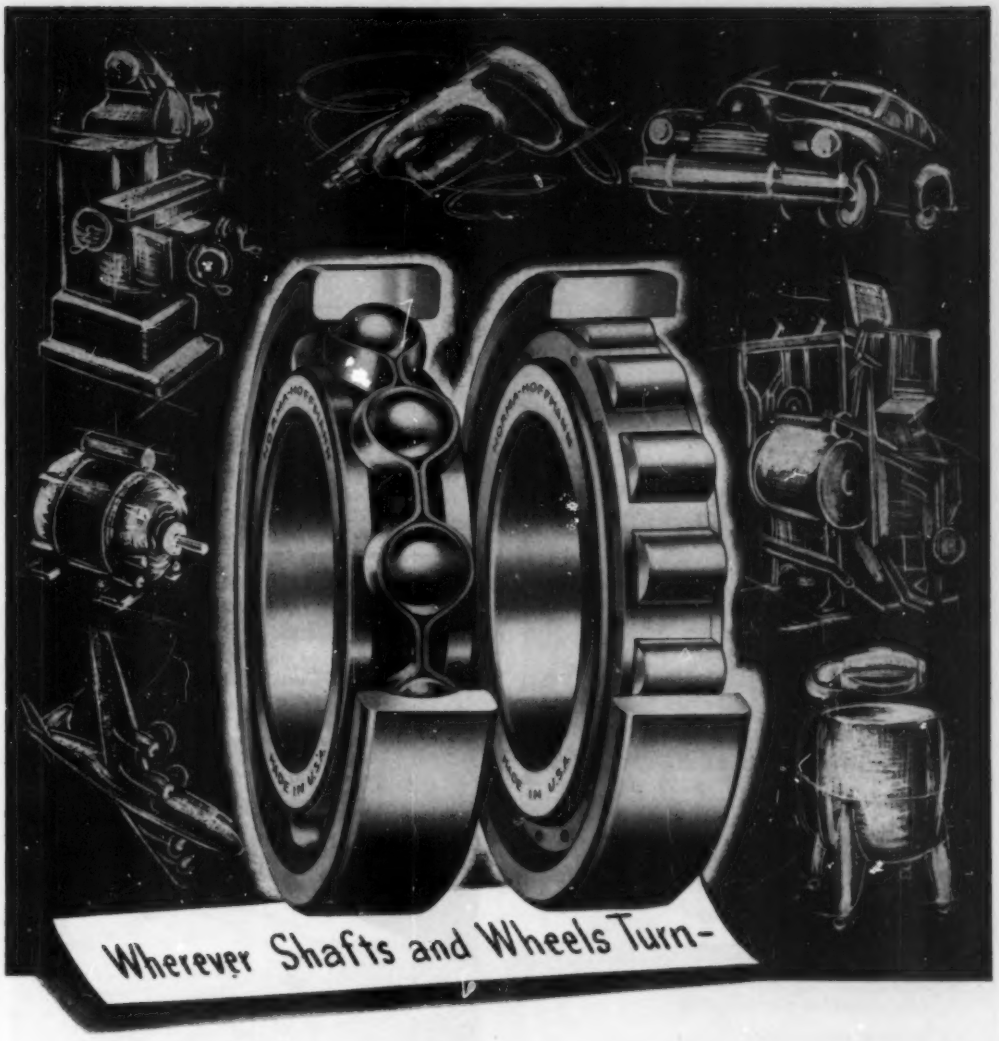
10 DAYS' FREE EXAMINATION

McGraw-Hill Book Co., Inc., 330 W. 42d St., NYC 18
Send me book(s) corresponding to the numbers encircled below for 10 days' examination on approval. In 10 days I will remit the price of the book(s) I wish to keep, plus a few cents delivery charge, and return unwanted books postpaid.*

1 2 3

Name .....
Address .....
City ..... Zone..... State.....
Company .....
Position PFE-2-50

* SAVE! We pay mailing costs if you send cash with this coupon. Same return privilege.



Year after Year
Norma-Hoffmann
Precision Bearings
Serve Efficiently

Norma-Hoffmann Engineers, specialists for over 35 years in bearing design and application, are available for consultation.

NORMA-HOFFMANN *Precision* BEARINGS
RAY ROLLER PRECISION

NORMA-HOFFMANN BEARINGS CORPORATION
STAMFORD, CONNECTICUT

FIELD OFFICES: Chicago, Cleveland, Detroit, Cincinnati, Los Angeles, San Francisco, Dallas, Seattle, Phoenix

A rugged one-piece foot leveling screw made possible ... only by COLD HEADING

actual size

Here is another example that shows what Scovill can do with cold heading to give a customer a finished part that is stronger and more reliable in service than if it were made by any other process.
If you need fasteners or other special parts in this general size range, check with Scovill first.

"Guide to the Profitable Use of Cold Heading"—Bulletin No. 2 describes the advantages and limitations of this process. If you have not received your copy, write today.

Recessed Head Screws • Sems • Tapping Screws
Standard Machine Screws • Special Cold Headed Parts

SCOVILL FASTENERS AND SPECIAL PARTS

INDUSTRIAL FASTENER SALES, WATERVILLE DIVISION
SCOVILL MANUFACTURING CO., WATERVILLE 14, CONN.

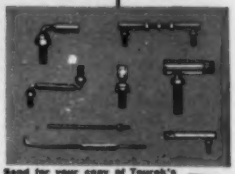
New York • Detroit • Wheaton, Ill. • Los Angeles • Cleveland • San Francisco

TOUREK BALL JOINTS and SCREW MACHINE PRODUCTS

1 BALL JOINTS

The use of Tourek Ball Joints has helped many manufacturers to improve product performance, simplify design and reduce costs. These benefits are yours too when you specify Tourek!.

Whether your specifications call for standard or special Ball Joints, you can depend upon Tourek performance, delivery and prices!



Send for your copy of Tourek's 16-page Ball Joint Catalog. It fully describes 12 standard types in 84 sizes (carried in stock), and has data on special types as well.

2 SCREW MACHINE PRODUCTS

Tourek's modern plant—from the tool room to the batteries of giant 6-spindle automatics—is geared to turn out your screw machine product needs in any size up to 2⅝", from any type of metal. Twenty-eight years of production experience back up every job which Tourek undertakes.

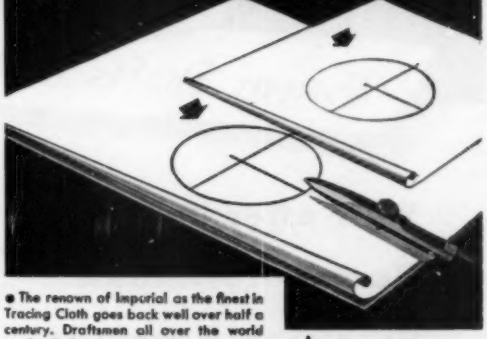
For prompt quotation on your screw machine products requirements, simply send blueprint or sample.

J. J. TOUREK MFG. CO.
4701 W. 16th St., Chicago 50, Ill.

MAKERS OF QUALITY SCREW MACHINE PRODUCTS

ESTABLISHED 1925
TOUREK
FAMOUS BALL JOINTS

TRACING CLOTH THAT DEFIES TIME



● The renown of Imperial as the finest in Tracing Cloth goes back well over half a century. Draftsmen all over the world prefer it for the uniformity of its high transparency and ink-taking surface and the superb quality of its cloth foundation.

Imperial takes erasures readily, without damage. It gives sharp contrasting prints of even the finest lines. Drawings made on Imperial over fifty years ago are still as good as ever, neither brittle nor opaque.

If you like a duller surface, for clear, hard pencil lines, try Imperial Pencil Tracing Cloth. It is good for ink as well.

IMPERIAL TRACING CLOTH

SOLD BY LEADING STATIONERY AND DRAWING MATERIAL DEALERS EVERYWHERE

DIE CASTING
produces parts and products in "jig-time"

CASE HISTORIES FROM MT. VERNON FILES

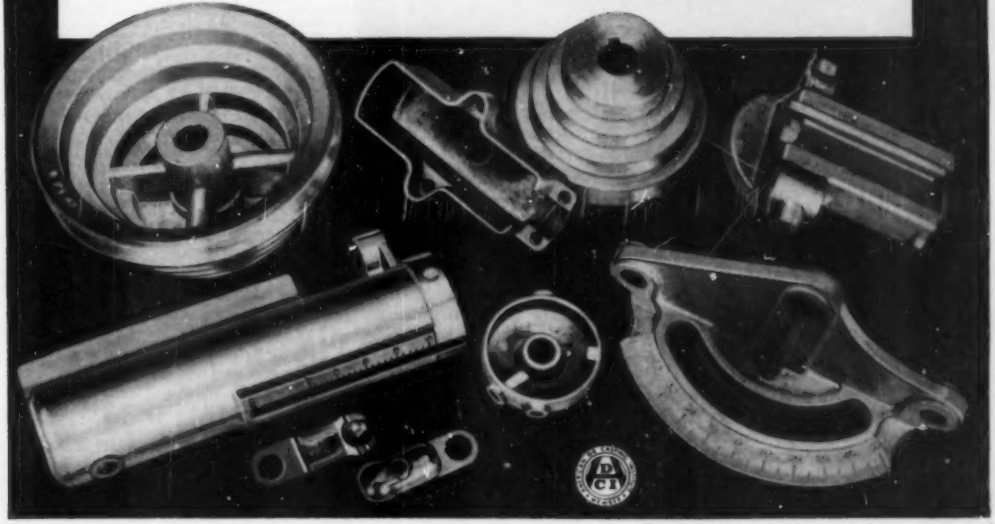
Rapid production—that's die casting's "middle name"; because any product, simple or complex, can be produced almost instantly by die casting . . . and time-consuming machining operations are reduced to a minimum or eliminated, entirely.

Look at these components of the new Walker-Turner 24-inch, 4-speed jig saw: intricate shapes—with bosses, holes, runners, guides; pulley sheaves for variable speed drives; parts bearing graduated scales. All are produced rapidly by Mount Vernon—so accurately, they require little or no machining; so clean, they can be adapted to any type of finish.

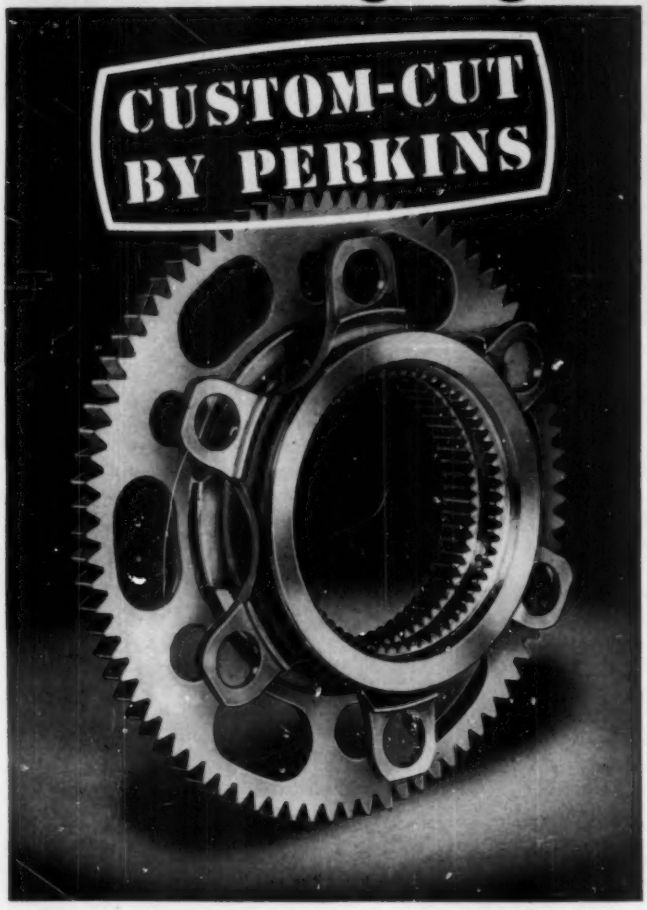
Yes, die casting means cost-cutting all along the line—savings in time, effort and material that team to slice unit costs.

Have you weighed your present manufacturing procedure against the many advantages of die casting? If not, consult with us. We feel confident we can show you the way to new production economies and product improvements—profitable operation in today's highly competitive market.

MT. VERNON
DIE CASTING CORP.
MT VERNON NEW YORK



AIRCRAFT engine gears



The highly complex gear shown here, is an example of the exacting production jobs entrusted to us regularly by many of the country's leading manufacturers of aircraft engines. Moreover, our ability in the field of gear engineering extends into practically every industry. Thus a vast amount of *all* types of equipment in use right now has been built at less cost and operates more efficiently because Perkins' engineers checked the customers' blueprints and specifications prior to manufacture.

Broad experience both in the application and manufacture of all types of gears has equipped our staff to bring to your project a highly specialized knowledge of power transmission problems.

For the manufacture of the highest quality gears in production quantities, consult PERKINS first.

PERKINS MAKES—In all materials, metallic and non-metallic—Helical Gears, Bevel Gears, Ratchets, Worm Gears, Spiral Gears, Spur Gears with shaved or ground teeth, Ground Thread Worms

PERKINS MACHINE & GEAR Co., West Springfield, Mass.

How to
Plan and Control Production
—for greater speed and efficiency

This guide brings you tested and improved methods of routing, scheduling, dispatching, inspecting, following-up.

PRODUCTION CONTROL

By L. L. Bethel, W. L. Tann, F. S. Atwater and E. E. Rung

Second Edition, 284 pp., illustrated, $3.50

You can get greater volume at lower cost with these successful methods of production planning and control. This guide book helps you handle more effectively your everyday problems of routing, scheduling, dispatching, inspecting, and following-up. Based on practical experience, it reflects current factory methods in more than 185 representative companies in all types of industries.

It brings you the principles behind improved control systems . . . hundreds of techniques and actual industrial cases. Operation analysis—budgeting costs—preparing a master schedule—translating orders into production—following-up — inspection — record keeping — these and scores of other planning and control methods are analyzed and evaluated.

Gives you up-to-the-minute guidance on:

Forecasting of sales and production volume—control of inventories and costs—methods of classification and identification—master route cards—keeping stores records—what "control" means to the plant organization—and methods of expense distribution. Put this handy volume to work on your production line . . . to help locate problem-areas and develop a sound system of controls for your plant.

Check these 15 "how-to" chapters:

1. The Concept of Control
2. Organization for Control
3. Production Forecasting
4. Product Development
5. Production Analysis
6. Relating Budgeting to Production
7. Routing of Operations and Processes
8. Scheduling Production
9. Dispatching
10. Follow-up—Expediting
11. Control of Materials
12. Classification and Identification
13. Quality Control
14. Relating Cost to Production
15. Coordination

10 DAYS FREE EXAMINATION

McGRAW-HILL BOOK CO., Inc.
330 W. 42nd St., N.Y.C., 18, N. Y.

Please send me a copy of Bethel's PRODUCTION CONTROL for 10 days' examination on approval. In 10 days I will remit $3.50, plus a few cents postage, or return book postpaid.*

Name .....
Address .....
City and State .....
Company .....
Position PPE-2-50

* SAVE! We pay postage and packing charges if you send cash with your order. Same return privilege.

You can make them better with COLD-FINISHED

J&L JALCASE

The original
Free Machining Cold-Finished
OPEN HEARTH STEEL

J&L STEEL

IF YOU WANT
GOOD
. . . machinability
. . . heat treating properties
. . . high cold-drawn physical properties
SAY
J&L JALCASE

★ **Available in a range of grades to suit a wide variety of applications.**

★ **Supplied as cold-drawn or cold-drawn-with-metallurgical-processing, which includes special tempering.**

Typical Jalcase analyses are found in the A.I.S.I. 1100 series. The usual manganese content is 1.00% to 1.65%. J&L, as the originator of these grades, can give you the benefit of years of know-how in the making of steel and the application of Jalcase to your particular requirements.

Some part you are now making can be made *better* from Jalcase with savings in money and time. Write us for a copy of "You Can Make Them Better With Cold-Finished Jalcase."

JALCASE STEEL IS QUALITY CONTROLLED FROM OUR OWN MINES THROUGH THE FINISHED PRODUCT.

JONES & LAUGHLIN STEEL CORPORATION

From its own raw materials, J&L manufactures a full line of carbon steel products, as well as certain products in OTISCOLOY *and* JALLOY (*hi-tensile steels*).

PRINCIPAL PRODUCTS: HOT ROLLED AND COLD FINISHED BARS AND SHAPES • STRUCTURAL SHAPES • HOT AND COLD ROLLED STRIP AND SHEETS • TUBULAR, WIRE AND TIN MILL PRODUCTS • "PRECISIONBILT" WIRE ROPE • COAL CHEMICALS

Jones & Laughlin Steel Corporation
409 Jones & Laughlin Building
Pittsburgh 30, Pennsylvania

Please send me a copy of your booklet, "You Can Make Them Better With Cold-Finished Jalcase."

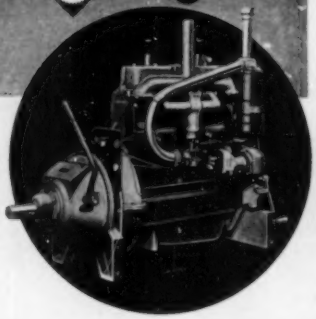
NAME_____

COMPANY_____

ADDRESS_____

Get the Right "POWER FIT" on your Products..

Use Rugged A-C Engines



No need to underpower your products — or waste money on engines that are too big. Five sizes of A-C Engines give you a "power fit" for *any* requirement, from 15 brake hp. up. Use them singly, or use two or more together instead of one larger costlier engine.

Designed for tough tractor service, A-C Power Units have the high torque to hang onto overloads — the stamina to stay on the job and keep users satisfied. Mass produced, along with tractor engines by the thousands, their first cost is low. They are economical to operate, too — on gasoline, low-grade fuel, natural gas or butane. Both open and enclosed models, with accessories to fit the application. Service and dependable A-C parts available at thousands of dealers.

Let our engineers help you get the right "power fit" for *your* products.

A Model to Fit Your Needs

MODEL*	R.P.M.	MAXIMUM BRAKE HP.
B-125	1500—1800	24.5—28.0
W-201	1400—1800	33.5—40.5
U-318	1200—1400	45.0—50.9
E-563	1050	74.0
L-844	1050	110.0

*Figures represent cu. in. piston displacement. — Also 13.5 hp. Industrial Wheel Tractors, and Diesel Crawler Tractors 37 hp. and larger.

ALLIS-CHALMERS
TRACTOR DIVISION — MILWAUKEE 1, U. S. A.

"COMMERCIAL"

A hand actuated compact hydraulic power unit for use anywhere — no power take off or motor needed — light weight, self contained, double acting pump that can be used with cylinders having lifting capacities up to 8000# — works in any position.

Few moving parts mean low maintenance.

Write for complete details.

THE COMMERCIAL-SHEARING & STAMPING CO.
P. O. BOX 719 YOUNGSTOWN 1, OHIO

Improve Your Product THROUGH VIBRATION Fatigue Tests

MODEL 100VA
CAPACITY 100 Lbs.
Produces Vibrations Vertically

YOU can definitely ascertain how good your product is—substantiate construction and design—eliminate excessive material—through interpreting tests made on the All American Vibration Testing Machine. Eight models for handling parts or assemblies from 10 lbs. to 100 lbs. in weight. Models for vertical and horizontal movement of table. Vibration in simple harmonic motion. Standard machines produce frequencies of 600 to 3,600 v.p.m., manually or automatically controlled. Send for Catalog F. Special machines designed and built to meet your requirements.

Makers of the Illuminated Layout Plate with 16X Microscope.

ALL AMERICAN
Tool & Manufacturing Co.
1012 W. FULLERTON AVE. CHICAGO 14, ILL.

The Lubrication of Sleeve Type Bearings-I

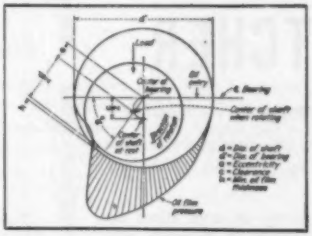
EFFICIENT bearing performance is governed to a great extent by the selection of the bearing material, the bearing design and the method of lubrication. By determining these factors, in relation to the operating conditions, we have the basis for the selection of the proper bearing to deliver the desired performance.

In consideration of the lubrication factor, we must determine the following points: Speed, load, viscosity of lubricant, bearing material, clearance, bearing design, nature of the rubbing surfaces, operating temperature and method of feeding and distribution of lubricant.

While the primary purpose of lubrication is to eliminate mechanical friction and to prevent wear and corrosion, no appreciable amount of power can be transmitted on the best of bearing materials without definite lubrication. Heat develops rapidly when the shaft operates in direct contact with the bearing. Heat is also developed beyond the normal radiating capacity if the viscosity of the lubricant is too high in relation to the speed of the shaft.

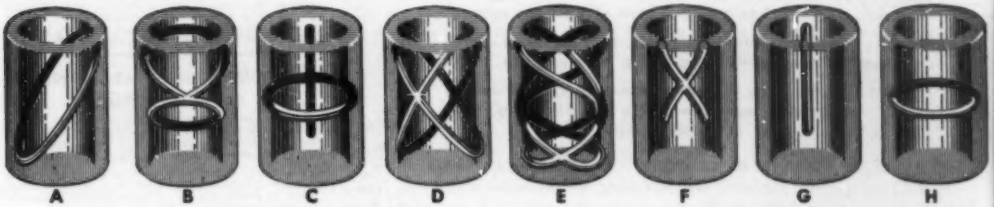
It is a mistaken idea that any type of oil or grease will provide suitable lubrication. The extensive research accomplished by the producers of lubricating materials enables any user of bearings to select the exact type required for his applications. In certain applications it is necessary to provide protection to the lubrication by the use of seals or the design of the bearing. This prevents the lubricant from seeping out with consequent loss and damage to material in process.

With the starting of the shaft the frictional resistance is high. As the speed increases, the lubricant under the influence of the moving part, plus its adhesive qualities, builds up a relatively thick film between the surfaces at the point of nearest approach. The shaft then undergoes a displacement in a direction at right angles to the line of load. The continued speed of the shaft creates a film pressure which increases until an equilibrium is established.



* * *

THE CURVE, as shown at left, represents the distribution of the calculated values of pressure in relation to the bearing reaction. The load-carrying capacity is governed by the maximum pressure that can be developed under the existing conditions. If the load pressure is down—as illustrated—then the curve indicates that the lowest pressure is practically opposite. Obviously this is the proper place for the intake of the lubricant.



Oil Grooving

● The purpose of oil grooves is to assure proper distribution of the lubricant along the length of the bearing in the region just ahead of the loaded area (see above). Complicated and elaborate grooves are in most bearings neither necessary nor useful; they render manufacturing more difficult, and, if not properly placed and executed, may do more harm than good because they may assist in interrupting the oil film.

Deep grooves should always be avoided and both edges of any oil groove should be rounded off to permit free entrance of the oil into the clearance.

Grooves should never be located in the high-pressure area of an oil lubricated sleeve bearing.

In order to obtain quick and uniform distribution of the oil along the length of the bearing, the oil groove should extend axially from the point of entrance and should stop short of the ends of the bearing to minimize oil leakage.

In applications where the direction of rotation changes, spiral oil grooves approaching the high-pressure area, like those shown in (a) and (b), might be expedient.

In many types of split-half bearing, especially when pressure lubrication is used, longitudinal chamfers (relieves) on each side of the bearing halves, are sufficient to secure distribution along the length of the bearing.

As to the points of the oil entry into the oil grooves, they should always be located ahead (relative to the direction of the shaft rotation) of the pressure area; that is, in the unloaded side in bearings with constant load direction.

In applications with changing load direction, the oil entry should be placed at points of minimum oil pressure.

For very long bearings, two oil entrances might be expedient or necessary; if so, they should be connected by one axial distributing groove.

Engineering Service

Johnson Bronze offers manufacturers of all types of equipment a complete engineering and metallurgical service. We can help you determine the exact type of bearing that will give you the greatest amount of service for the longest period of time. We can show you how to design your bearings so that they can be produced in the most economical manner. As we manufacture all types of Sleeve Bearings, we base all of our recommendations on facts free from prejudice. Why not take full advantage of this free service?

This bearing data sheet is but one of a series. You can get the complete set by writing to—

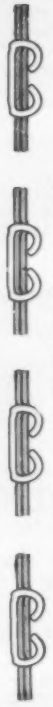
Johnson Bronze

SLEEVE BEARING HEADQUARTERS
508 S. MILL ST. • NEW CASTLE, PENNA.

Fastening Operations Cost Less with an

ACME-MORRISON METAL STITCHER

Composition board and impregnated fibreboard being fastened together with the Acme-Morrison Metal Stitcher.



CROSS-SECTION VIEWS OF STITCHES

and are done faster . . . stronger . . . neater

If you fasten sheet metal to metal or any non-metallic material, here's why you should do the job with an Acme-Morrison Metal Stitcher:

1. ***To save time.*** **In one operation, forms its own stitch or staple from a continuous coil, drives it through the material, and clinches it at the rate of 280 per minute.**
2. ***To save material.*** **Replaces rivets, screws, nails, bolts and spot welding with inexpensive wire stitches.**
3. ***To save money . . .*** **by increasing production, eliminating costly, unnecessary operations. No pre-punching, predrilling, matching or inspection required.**

For example: A furnace manufacturer cut an assembly cost from 17½c to 3½c per unit by replacing rivets with wire stitches. A maker of insecticide spray guns reduced his labor costs 38%, and cut material costs 91%, by replacing two screws with wire stitches.

Find out how similar savings can be applied to your assembly line. Mail the coupon today.

STITCHING WIRE DIVISION

ACME STEEL COMPANY

NEW YORK 17 ATLANTA CHICAGO 8 LOS ANGELES 11

ACME STEEL COMPANY, Dept. PE-20
2840 Archer Avenue, Chicago 8, Illinois

☐ Send booklet on *"Metal Stitching."*
☐ Have representative call.

Name _____

Company _____

Address _____

City _____ Zone _____ State _____

Aluminum, leather and copper stitched together

Aluminum, plywood and brass stitched together

Textile stitched to aluminum

CHECKLIST of outstanding McGRAW-HILL BOOKS

1. VIBRATION and SOUND

By Philip M. Morse, Director, Brookhaven National Laboratory

468 pages, 116 illustrations, $5.50

Here's authoritative information on the theory of vibration and sound—factual material on strings . . . the case of plane waves in tubes . . . and the application of operational calculus and the Laplace transform to the study of acoustical transients. This book explains and analyzes the simple oscillator, the flexible string, the vibration of bars, membranes, and plates, plane waves of sound, the radiation and scattering of sound, standing waves of sound, etc.

2. MECHANICAL VIBRATIONS

By J. P. Den Hartog, Professor of Mechanical Engineering, M. I. T.

3rd edition, 478 pp., 6x9, 282 illus., $6.00

This book deals with vibrational phenomena in a technical manner, yet emphasizes applications of principles and calculations to practical problems of vibration. You receive valuable information on airplane wing flutter, helicopter ground vibration, torsional pendulum dampers, singing ships' propellors, and electronic instruments. The principal applications to steam turbines, automobiles, diesel engines, and electrical machinery are included.

3. MATHEMATICAL THEORY of ROCKET FLIGHT

By J. Barkley Rosser, Professor of Mathematics, Cornell University—**Robert R. Newton,** Technical Staff Member, Bell Telephone Laboratories, Inc.—and **George L. Gross,** Research Engineer, Grumman Aircraft Engineering Corporation.

276 pp., 6x9, 41 diagrams, $4.50

Explanations and illustrations in this volume are combined with mathematical analysis to show you factors involved in rocket propulsion. Discoveries in the field are covered by a wealth of explanatory material including concise diagrams, tables, and graphs. Covers such points as how jet forces propel the rocket, how the rocket is rotated for stability, aerodynamic forces on a non-spinning rocket, effect of jet action, dispersion of a rocket, vacuum trajectory, launcher velocity, and tipping-off effects.

4. COMPUTING MECHANISMS and LINKAGES

By Antonin Svoboda, Hubert M. James, Editor, Vol. 27—Massachusetts Institute of Technology Radiation Laboratory Series. OSRD-NDRC.

353 pp., 6x9, 177 illus., $4.50

This guide to recent developments in radar gives you a clear picture of computing mechanisms in general, and includes a detailed study of the design of bar linkages for use in computers. You receive a full account of novel methods for the design of bar linkages as generators of functions of one and two independent variables. Special attention is given to the design of bar linkage multipliers.

10 days free examination

McGRAW-HILL BOOK CO., INC.
330 W. 42nd St., N. Y. C. 18

Send me books corresponding to numbers circled below for 10 days free examination on approval. In 10 days I will pay for books I wish to keep, plus a few cents postage, and will return unwanted books postpaid.*

1. 2. 3. 4.

Name .....

Address .....

City ..... Zone.... State.....

Company .....

Position PPE-2-50

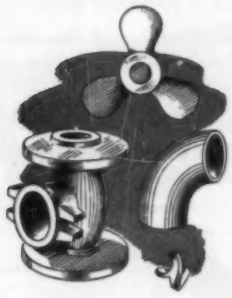
* SAVE! We pay postage and packing charges if you send cash with your order. Same return privilege.

SOLVE YOUR CORROSION PROBLEM

with one of these forms of HASTELLOY alloys
TRADE-MARK

You can obtain HASTELLOY nickel-base alloys in a variety of forms to meet every requirement for high strength and resistance to heat and corrosion. These alloys compare in strength to the high-strength alloy steels, and maintain high strength even at elevated temperatures. HASTELLOY alloys are particularly suitable for equipment that must handle hydrochloric and sulphuric acids . . . free chlorine . . . aqueous solutions containing chlorine or hypochlorites . . . acid solutions of ferric or cuprous salts . . . brine and salt spray.

These alloys can be readily fabricated. Any shop equipped to fabricate the austenitic stainless steels can fabricate them. If you do not do your own fabricating work, we can give you the names of fabricators familiar with handling HASTELLOY alloys. Write for descriptive literature and price lists.



CASTINGS

Simple or intricate sand castings up to 2,000 lb. Precision investment castings in a variety of intricate shapes up to 5 lb.

PIPE AND PIPE FITTINGS

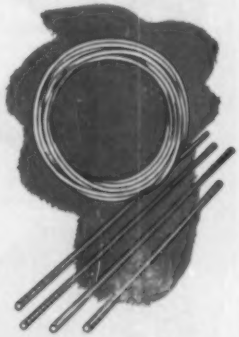
Cast or drawn pipe and welded tubing. Welding, flanged, and threaded fittings in a wide range of standard and special styles and sizes.

SHEET, PLATE, AND BAR STOCK

Hot-rolled sheet and plate down to 23 B.w.g. (0.025 in.), in widths up to 36 in. Hot-rolled bars from ¼ in. to 3½ in. in diameter.

WELDING ROD, ELECTRODES, AND DRAWN WIRE

Bare rod for oxy-acetylene, HELLARC, or atomic hydrogen welding. Coated electrodes for metallic-arc welding. Wire coils for UNIONMELT welding, metal-spraying, and fabricated wire products.



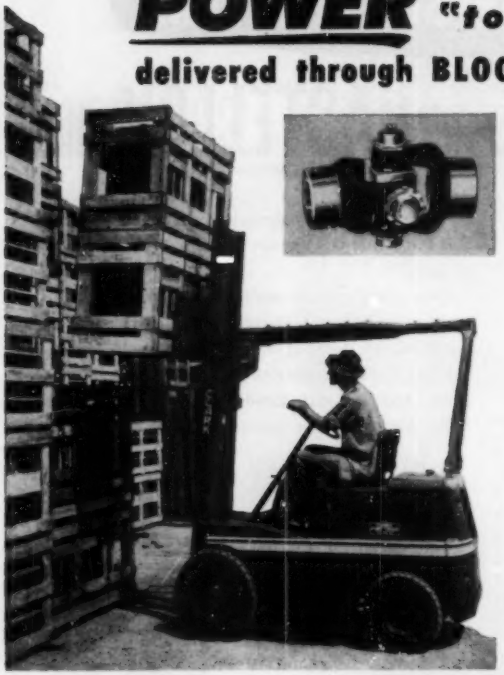
HAYNES *alloys*
TRADE-MARK

Haynes Stellite Division
Union Carbide and Carbon Corporation
UCC
General Offices and Works, Kokomo, Indiana
Sales Offices
Chicago — Cleveland — Detroit — Houston
Los Angeles — New York — San Francisco — Tulsa

The terms "Haynes," "Hastelloy," "Hellarc," and "Unionmelt" are trade-marks of Union Carbide and Carbon Corporation or its Units.

POWER "to come back for more"

delivered through BLOOD BROTHERS universal joints



This high-speed fork truck takes a beating on the job. To stay in action—under rugged conditions—machines like this require universal joints that are tops for toughness and stamina. That's why all these lift truck manufacturers specify Blood Brothers Universal Joints:

Clark Equipment Company
Towmotor Corporation
Gerlinger Carrier Company
Hyster Company
Ross Carrier Company

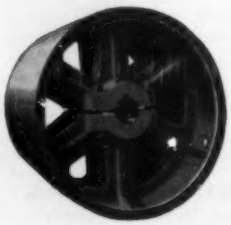
Blood Brothers will assist you in three ways: by recommending the proper joint for each application . . . by furnishing prompt, experienced engineering service . . . by dependably supplying your production needs.

When you need power delivered through dependable universal joints, specify Blood Brothers. Write for our complete catalog.

BLOOD BROTHERS machine co.
Division of Standard Steel Spring Company
ALLEGAN, MICHIGAN Chicago Office: 122 S. Michigan

High test cast iron pulleys in all sizes and types

Completely split pulley



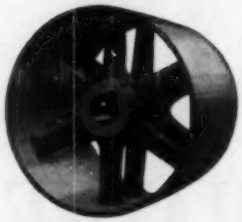
Extra heavy conveyor pulley

JONES cast iron pulleys are true running — they permit higher speeds — no bushings and they can't fall apart — they don't rattle and they look better on most machines.

These pulleys are machine molded, poured of high test cast iron, and are accurately finished and balanced. Multiple piece pulleys, rubber covered pulleys and flywheels can be furnished.

W. A. JONES FOUNDRY & MACHINE CO.
4417 Roosevelt Road, Chicago, Illinois

Single arm solid pulley



Double arm pulley

Jones

HERRINGBONE — WORM — SPUR — GEAR SPEED REDUCERS • PULLEYS
CUT AND MOLDED TOOTH GEARS • V-BELT SHEAVES • ANTI-FRICTION
PILLOW BLOCKS • FRICTION CLUTCHES • TRANSMISSION APPLIANCES

"Hy-Power" Hydraulics

"HY-POWER" HYDRAULICS, developed by Hannifin, has brought forth an entirely new concept of the high speeds and extreme forces that can be developed hydraulically with small, compact, automatic work units. Based on the use of 5,000 p.s.i. pressure through an ingenious mechanical cycle control unit, "HY-POWER" HYDRAULICS has gone far beyond its original application in the famed Hannifin "Hy-Power" Hydraulic Riveter. Today, hundreds of production engineers and tool designers are using "HY-POWER" HYDRAULICS as the key to faster, better production and lower costs for an almost unlimited range of applications. You, too, can benefit from this truly noteworthy development. Ask for the story of "HY-POWER" HYDRAULICS—it's contained in new bulletin just off the press!

HYDRAULIC PRESSURE GENERATORS

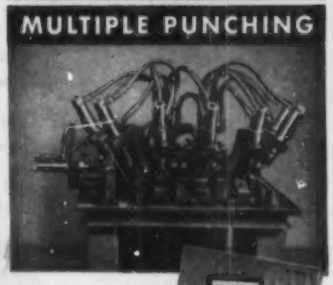
plus **TOOLS, CYLINDERS, AND MACHINES** *for*

HANNIFIN supplies everything you need to make "HY-POWER" HYDRAULICS work efficiently and dependably for you.

HYDRAULIC PRESSURE GENERATORS—The heart of the "Hy-Power" System! Up to 5,000 p.s.i. pressure at your finger-tip under exclusive automatic control. Occupies less than 6 sq. ft. of floor space, yet is capable of delivering hundreds of tons of useful force. 22 standard models.

"HY-POWER" HYDRAULIC CYLINDERS—Built to work at various pressures up to 5,000 p.s.i. pressure. Heat treated alloy steel bodies with precision ground bore. Alloy steel rod, case hardened and ground. 9 standard sizes, 2" to 7¼" bore.

COMPLETE MACHINES—"Hy-Power" work units are easy to apply and use in machines of your own design or construction. Hannifin also offers a complete line of standard and specially made portable and stationary Riveters, Punches, Presses, Multiple Riveting Machines, and Multiple Punching Machines.



ASK FOR A COPY OF THIS *New* BULLETIN

● It tells the complete story of "HY-POWER" HYDRAULICS. 28 pages of equipment, application, and engineering data. Ask for Bulletin 150.

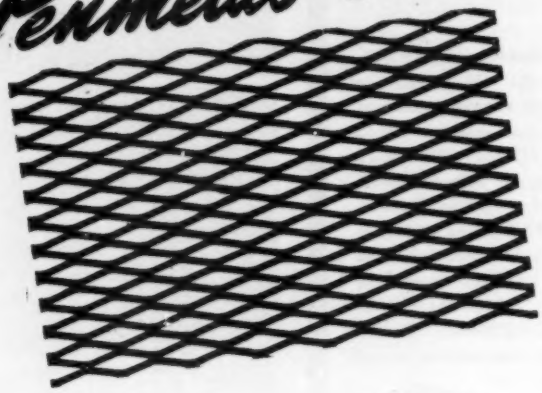
HANNIFIN CORPORATION

1125 SO. KILBOURN AVENUE, CHICAGO 24, ILLINOIS

AIR CYLINDERS • HYDRAULIC CYLINDERS • HYDRAULIC PRESSES
PNEUMATIC PRESSES • HYDRAULIC RIVETERS • AIR CONTROL VALVES

NOW *IN THE FINEST MESH EVER PRODUCED*

Penmetal **MINIMESH EXPANDED METAL**



AVAILABLE
Standard or Flattened
in
Carbon Steel
and other Metals

This shows actual size

3/16" x 1/2" MESH

4' x 8' sheets

22 gauge metal

Light weight —less than ½ lb. per square foot— 80% lighter than solid sheet.

Exceptional strength —more rigidity than solid sheet due to the diamond truss characteristic.

Unusual beauty —for ornamental work—grilles—inserts—panels and many other uses.

Great versatility —can be readily cut, formed or shaped; can be weldered, soldered or brazed; can be used unfinished, painted, polished, enamelled, galvanized.

Samples and name of nearest distributor are yours for the asking

Penmetal EXPANDED METAL is available also in ½" to 1½" diamond mesh, No. 20 to No. 9 gauge, carbon steel, stainless steel, aluminum.

81st PENMETAL YEAR

Penmetal

PENN METAL COMPANY, INC.

General Sales Offices: 205 East 42nd Street, New York 17, N. Y.

District Sales Offices

Boston · New York · Philadelphia · Chicago · Detroit · Indianapolis
Seattle · Los Angeles · San Francisco · Dallas · Parkersburg, W. Va.
Factories: Parkersburg, W. Va.

SPEED CONTROL *for* **Electrical Drives**

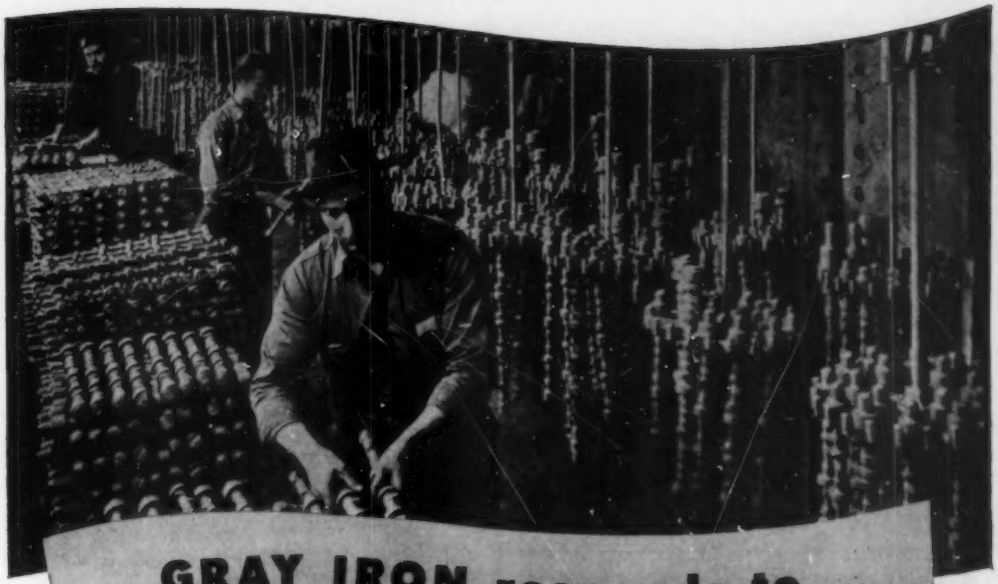
You probably read this authoritative and helpful feature article in the January issue of PRODUCT ENGINEERING. Concisely written, it surveys performance characteristics and equipment requirements. Charts and drawings graphically illustrate important design factors discussed in its 32 pages.

For those who would like copies of this basic treatise for distribution to their technical staffs, we have a supply on hand.

Reprints in booklet form are available in limited quantities at 25¢ each from Reader Service Department.

•

PRODUCT ENGINEERING
330 W. 42ND STREET
NEW YORK 18, N. Y.



GRAY IRON responds to HEAT TREATMENT

Automobile camshafts require a very hard wearing surface where they make millions of contacts with valve lifters. This is readily achieved by flame hardening and quenching of the Gray Iron castings.

Gray Iron also responds to induction hardening and other standard heat-treatments. Wear resistance can be increased up to many times that of the conventional as-cast material.

Because of its unique structure, Gray Iron can be hardened with minimum distortion, often with no necessity for subsequent stress relief or dimensional correction.

Make It Better With Gray Iron

Second largest industry in the metal-working field

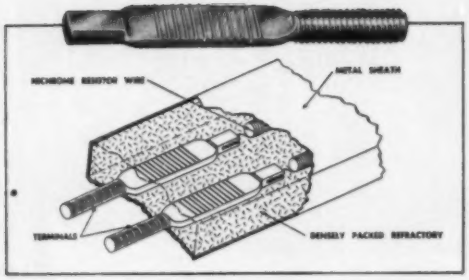
Are you taking full advantage of the extraordinary combination of useful properties offered by Gray Iron? These characteristics include:

- Castability
- Rigidity
- Low Notch Sensitivity
- Wear Resistance
- Heat Resistance
- Corrosion Resistance
- Machinability
- Vibration Absorption
- Durability
- Wide Strength Range

GRAY IRON FOUNDERS' SOCIETY, INC.

NATIONAL CITY-E. 6th BLDG., CLEVELAND 14, OHIO

HOT ASSIGNMENT
for this PROGRESSIVE *fastener*



Edwin L. Wiegand Company uses this terminal pin on their versatile Chromalox seamless blade-type immersion heaters, which operate as high as 750°F. It is one of many special fasteners made by Progressive.

The design provides for electrical clearance between the pin and the metal heating blade casing — for secure fastening of the pin in the refractory — and for attaching electrical wiring connections.

Progressive is equipped to handle special fastener production with speed, precision and economy. Do what many leading manufacturers do — IF IT'S SPECIAL, see PROGRESSIVE.

WRITE FOR OUR CATALOG
IT MAY SAVE YOU MONEY

Other typical PROGRESSIVE *"Specials"*

QUALITY PROMCO BRAND

THE PROGRESSIVE
MANUFACTURING COMPANY
48 NORWOOD ST., TORRINGTON, CONN.

SALES OFFICES: SAN FRANCISCO, LOS ANGELES, PORTLAND, DETROIT, PHILADELPHIA, CLEVELAND, SEATTLE, BOSTON, SYRACUSE, ST. LOUIS, CHICAGO.

DESIGN FOR COMPETITION..

To meet the exacting needs of a buyer's market every detail of production must be engineered for precision — quality and performance.

Diefendorf engineers the design and production of gears of all types and materials to meet exacting specifications.

DIEFENDORF GEAR CORP.
Syracuse, New York

DIEFENDORF
GEARS

DO YOU KNOW?

—that a PILOT LIGHT CAN IMPROVE YOUR PRODUCT
. . . add attraction—safety—service?

Ask DIALCO
— what lamp to use
— how to use it
— what it will do
— what it will cost

THIS MAY BE THE ONE
Designed for low cost NE-51 Neon
• Built-in Resistor • Patented
• U/L Listed • Rugged
Catalogue Number 521308 — 997
for 110 or 220 volts.

SAMPLES
for design purpose
NO CHARGE

NEW! Write for the "HANDBOOK OF PILOT LIGHTS."
Write us on your design problems.

Foremost Manufacturer of Pilot Lights
The DIAL LIGHT COMPANY of AMERICA
900 BROADWAY, NEW YORK 3, N. Y.

Looking for a Possible Variation in the "Fluff"

Precision in the making of corrugated shipping containers is as essential as in the manufacture of the thousands of products these containers carry safely to their destinations. In the mills of The Ohio Boxboard Company at Rittman, Ohio, the Strobotac checks several manufacturing operations, not the least of which is shown above. Here are the how and the why in their own words:

> "The beam was focused on the single facer where the corrugated medium (.009" straw) left the flute roll and "fluffed" out on the fingers before the adhesive is applied. The "fluff" must be uniform to achieve uniform adhesion, otherwise blisters will form. Even though we had to use a double image, due to the frequency being about 360 per minute, we were able to spot faulty finger adjustment which resulted in blistered board. By use of the Strobotac we were able to correct faulty adjustment very quickly."

Here, as in hundreds of instances, the Strobotac flash, by "stopping motion," reveals conditions and causes, effects and defects, previously hidden or obscured.

TYPE 631-B

STROBOTAC

Direct-Reading Flashing Speed Range: from 600 to 14,400 per minute — stops motion from 100 to 100,000 rpm.

Flash Duration: between 5 and 10 microseconds.

Power Supply: 115 volts, 60 cycles.

Power Input: 25 watts.

Dimensions: 7½ x 8¼ x 9½ inches.

Price: $125.00

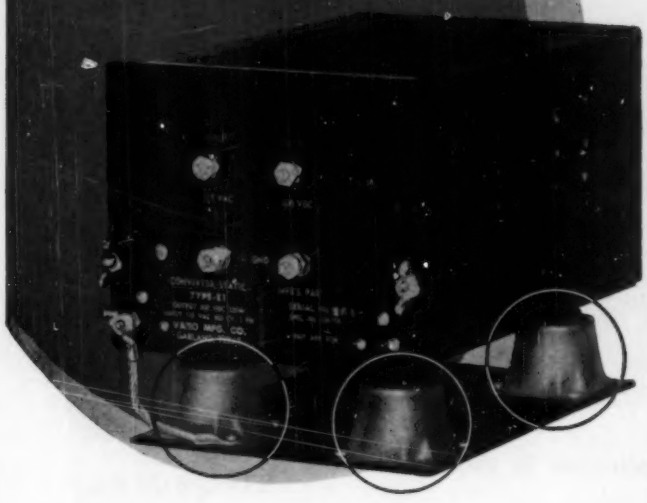
Write for your 24 page manual of stroboscopic techniques, "Eyes for Industry."

GENERAL RADIO COMPANY Cambridge 39, Massachusetts

90 West St., New York 6 920 S. Michigan Ave., Chicago 5 1000 N. Seward St., Los Angeles 38

Protected Performance!

with LORD BONDED RUBBER MOUNTINGS



Varo Static Converters change alternating to direct current for aircraft use with *less than 1% voltage ripple.* LORD Mountings protect such precision against shock and vibration, thus insuring the user long and dependable service.

More and more manufacturers of sensitive equipment appreciate the customer satisfaction which LORD Vibration-Control Mountings add to their products. Builders of heavier mechanical equipment use them to provide smoother, quieter operation . . . greater sales appeal. If you are interested in product improvement, investigate LORD Mountings now.

LORD BONDED RUBBER **Vibration Control**

LORD MANUFACTURING COMPANY · ERIE, PA.

Canadian Representative: Railway & Power Engineering Corp. Ltd.

How to select the right material for the right job

Practical data on

7500 MATERIALS

in the

Revised, Enlarged 6th Edition of

MATERIALS HANDBOOK

By GEORGE S. BRADY

789 pages, 6 x 9, $7.00

Here's your short cut to essential facts you need in the selection and specification of materials. It saves you endless time—and eliminates error—in the choice of materials for manufacturing, construction, engineering, chemical processing, etc. You get full descriptions of hundreds of processing materials used in the basic and intermediate industries—*plus* data on imported raw materials that the war emergency has shown to be important to American industries.

You get 7500 materials descriptions

Years of work have gone into selecting only the most pertinent facts about some 7500 materials, and presenting them in compact form for the convenience of industrial engineers, executives, architects, designers, builders, and purchasing agents. Arranged for instant reference this handbook gives chief characteristics, comparative data, sources, substitutes, adulterants, and uses. The chief ores and most important of industrial chemicals are included. A new section on materials economics gives you valuable details on procurement and use of materials throughout the world. It features a wealth of helpful charts, maps, tables, and illustrations.

10 DAY FREE EXAMINATION

McGRAW-HILL BOOK CO., INC.
330 West 42nd St., New York 18, N. Y.

Please send me a copy of Brady's MATERIALS HANDBOOK, 6th Edition, for 10 days' examination on approval. In 10 days I will remit $7.00, plus a few cents postage, or return book postpaid.*

Name .....

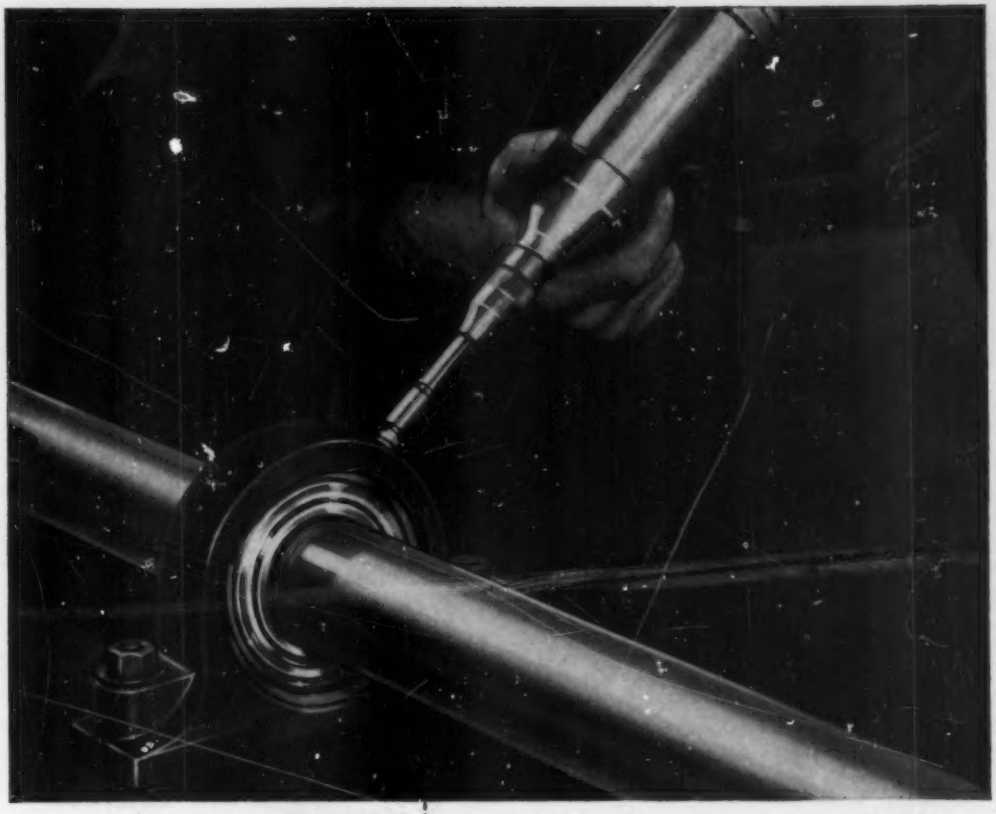
Address .....

City .....Zone.....State.....

Position .....

Company FPE-2-50

* SAVE! We pay postage and packing charges if you send cash with your order. Same return privilege.



NO, SIR!
The Seal Won't Blow!

DODGE TYPE "SC" BALL BEARING PILLOW BLOCK

Precision built bearing for small shafts and moderate loads. Pillow blocks, flange bearings and hanger bearings available from distributors' stocks in shaft sizes ranging from 3/4" to 2-7/16".

CALL THE TRANSMISSIONEER, your local Dodge Distributor. Factory trained, he can give you valuable assistance on new, cost saving methods. Look for his name under "Power Transmission Equipment" in your classified telephone book.

METALLIC-BACKED neoprene seals are used in this famous bearing—and they are engineered to *stay put.* They can't blow.

Your lubricant stays in; dust and dirt stay out; the result is years and years of trouble-free performance.

The "SC" Bearing is a new member of the Dodge 30,000 hour line. Modern styling. Rugged one-piece cast iron housing. Long inner race. Radial and thrust load capacity. Fully self aligning. *WRITE* for special "SC" bulletin, giving complete specifications.

DODGE MANUFACTURING CORPORATION, 1200 Union St., Mishawaka, Ind.

DODGE

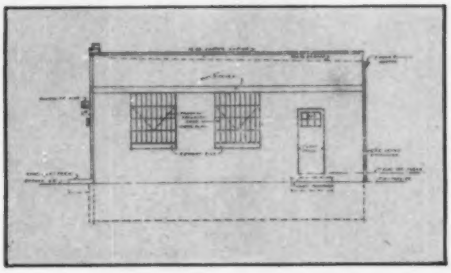
of Mishawaka, Ind.

FIRST IN POWER TRANSMISSION MACHINERY

FOR YOUR NAME PLATE REQUIREMENTS, WRITE OUR SUBSIDIARY, ETCHING COMPANY OF AMERICA, 1520 MONTANA STREET, CHICAGO 14, ILLINOIS

with CONCRETE

— the small extra first cost of test samples pays off in assurance of efficiency and durability of the finished structure.



with TRACING CLOTH . . .

The small extra first cost of Arkwright Tracing Cloth, over that of tracing paper, repays many times over in the efficiency and durability of valuable drawings.

Arkwright gives both immediate *and* future advantages. The expert work of the draftsman is made permanent. Your investment in time and money is backed by sharp, clean reproductive quality. Under repeated use — or on file for subsequent need — Arkwright assures perfect drawing performance year after year.

For every drawing worth keeping for future use — use permanent Arkwright instead of perishable tracing paper. Send now for generous samples and prove this superiority. Sold by leading drawing material dealers everywhere. Arkwright Finishing Company, Providence, R. I.

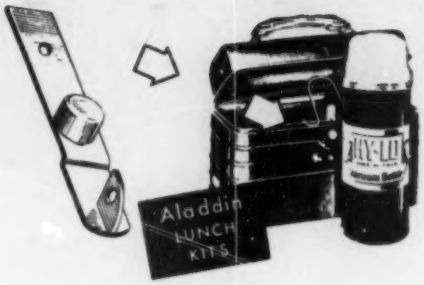
The Big Six Reasons Why Arkwright Tracing Cloths Excel

1. Erasures re-ink without feathering.
2. Prints are always sharp and clean.
3. Tracings never discolor or go brittle.
4. No surface oils, soaps or waxes to dry out.
5. No pinholes or thick threads.
6. Mechanical processing creates permanent transparency.

ARKWRIGHT

TRACING CLOTHS

AMERICA'S STANDARD FOR OVER 25 YEARS



THE PUSH BUTTON SPRINGLOCK is manufactured by CUYAHOGA!

MILLIONS of Cuyahoga wire parts and springs are doing a dependable job for industry on every conceivable type of product from lunch kits to automobiles.

If your product requires a spring or wire part, made from either round or flat wire, in any size, shape or metal, Cuyahoga's experience, skill and modern production facilities are available to you.

Send us your inquiries.

A SUBSIDIARY OF Barium STEEL CORPORATION

The CUYAHOGA SPRING Co.

10251 Berea Road, Cleveland 2, Ohio

NEW! DIFFERENT! NEW! DIFFERENT! NEW! DIFFERENT!

Effortless AIR CONTROL VALVES!

NEW! DIFFERENT! NEW! DIFFERENT!

Hand Operated

TYPE NH—A new hand-operated, four-way, directional air control valve. Sizes ⅛" and ¼". ⅜" lever motion.

Foot Operated

TYPE NF—A new foot-operated, four way, directional air control valve. Sizes ⅛" and ¼". With or without pedal guard.

HERE is the newest thing in air valves for operating single or double acting air cylinders! Built for *hand or foot* operation, these instant-acting valves provide fast, effortless control comparable to an electric valve—*at minimum cost.*

DISC TYPE; SELF-LAPPING—Metal-to-metal seat. Air tight. Packless.

PILOT CONTROLLED; PISTON OPERATED—Only light touch required; air does the work—shifts the main valve.

PRECISION ENGINEERED—Simple, compact, self-contained; rugged! Try one today. *Ask for bulletins.*

HANNIFIN *Corporation*

1125 S. Kilbourn Ave. • Chicago 24, Illinois

Now! Delco Appliance's Revolutionary

NEW RIGIDFRAME MOTOR

Available For Your Needs

Here's a new appliance motor— New in mechanical features— New in electrical performance

Rigidframe

In the new DELCO APPLIANCE RIGIDFRAME motor four welded struts lock the laminations in place and provide a rigid frame upon which the motor is assembled. The recent development of new welding techniques by Delco Appliance engineers makes possible this revolutionary type of motor construction which has superior mechanical features and electrical performance.

RIGIDFRAME CONSTRUCTION insures against misalignment frequently caused by rough handling in manufacture and shipping. The rigidity of the welded struts and motor end heads assures concentricity between stationary and moving parts—maintains positive bearing alignment, assuring freedom from binding or freezing. Magnetic noise is greatly reduced, too—with resultant quietness of operation.

RIGIDFRAME CONSTRUCTION allows maximum utilization of magnetic material—thus reduces electrical losses and improves electrical performance. This effective use of magnetic material results in a high pullout torque, which insures against burned out windings under heavier work loads.

In addition to these outstanding features the new DELCO APPLIANCE RIGIDFRAME motor has a one-piece, die-cast rotor and fan for added performance—a heavy duty starting switch which gives smooth, trouble-free starting under maximum loads—and nylon insulated windings covered with a thermo-setting insulation varnish, for freedom from electrical breakdown.

The new RIGIDFRAME motor is another example of the engineering and research that has made Delco Appliance a leader in the production of small motors. Whether you need a Split-Phase, a Series-Universal, or an automotive Heater and Defroster motor—you can depend on Delco Appliance design and quality. Our engineers will be glad to work with you in designing the motor to fit your exact needs.

NEW DELCO APPLIANCE RIGIDFRAME SPLIT-PHASE MOTORS for washing machines, ironers, blowers, control devices, office equipment, and other electrical appliances.

DELCO APPLIANCE AUTOMOTIVE HEATER AND DEFROSTER MOTORS. Also for seeders, small blowers, cooling and ventilating fans, and other appliances.

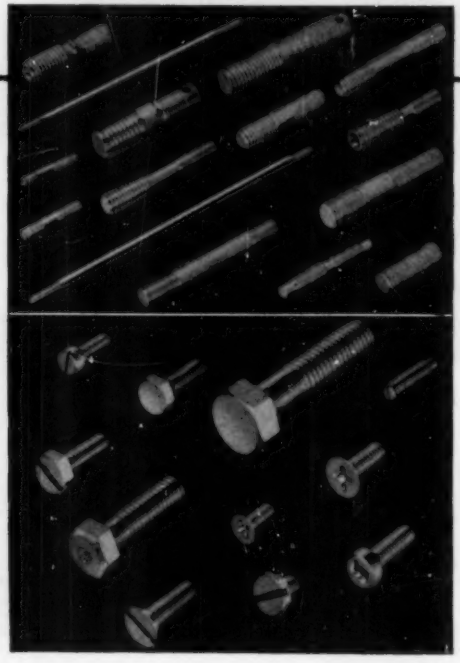
DELCO APPLIANCE SERIES-UNIVERSAL MOTORS for sewing machines, office machines, small blowers, motion picture projectors, farm machinery and other uses.

DELCO APPLIANCE DIVISION, General Motors Corp., Rochester, N. Y.

Also manufacturers of automatic Delco-Heat and Delco Water Systems for farms and homes.

NAT SAYS:
LOK-THRED is your best bet to insure...

MORE POSITIVE LOCKING HIGHER FATIGUE LIMITS



Lok-Thred bolts, studs and screws actually *become tighter in service.* Lok-Thred eliminates the need for selective fits and blind tapping, yet provides effective and positive sealing—with increased strength in both tension and torsion, and higher fatigue limits than any conventional threaded parts.

The uses of Lok-Thred are practically unlimited. For complete engineering and design data, *write for new Lok-Thred booklet.*

National
AIRCRAFT AND INDUSTRIAL
PRODUCTS

THE NATIONAL SCREW & MFG. COMPANY... CLEVELAND 4, OHIO

DID YOU FORGET

TO TELL US THAT YOU'RE MOVING ?

Planning to move? If you are, then won't you please let us know as far in advance as possible? It takes time to make address corrections on your PRODUCT ENGINEERING subscription stencil. By notifying us about your change in address, you make sure PRODUCT ENGINEERING reaches you. There's a handy coupon below to report the change to us. Do it now so you continue receiving your PRODUCT ENGINEERING without a single hitch in service. Thanks for cooperating!

PRODUCT ENGINEERING
Circulation Department
330 West 42nd Street, New York 18, N. Y.
CHANGE OF ADDRESS NOTICE

On or about.....my new address will be:

Street .....

City .....Postal Zone #... State ...

Signed .....

My old address is:

Street .....

City ..... Postal Zone #... State ...

Nowhere else in the world is so much candy manufactured

THE GREATEST FOOD PRODUCING CENTER IN THE WORLD
Chicago and Northern Illinois

One of the most important aspects of Chicago's food processing activities is its world leadership in the manufacture of candy. More than 95% of Illinois' $299,713,000 candy production comes from Chicago area manufacturers. In 1948, they accounted for 31% of the nation's $944,925,000 candy output. Many factors contribute to Chicago's leadership in the candy industry. Essential ingredients ... milk, butter, eggs, corn syrup and fruits are immediately available from the rich dairy, farm and orchard lands of the surrounding area. Unparalleled rail, water, highway and air transportation brings to the city the sugar, nuts, spices, oils and fruit from all over the world. Added to these are the advantages of the city itself, where specialized equipment for candy cooking, plentiful labor of every degree of training, skilled nutritional research resources, plus expert merchandising and distributing facilities, are ever abundant. The diversity of Chicago's candy products, from the finest packaged goods to the children's penny favorites, reflects the tremendous and varied resources available here to the candy industry. Numerous other industries enjoy similar benefits from location in the Chicago area. Should you wish information concerning Chicago's advantages for *your* business, we will gladly furnish you a confidential survey of conditions here, as they apply to your specific problem. There is no obligation, of course.

Industries in the Chicago area have these outstanding advantages: *Railroad Center of the United States • World Airport • Inland Waterways • Geographical Center of U. S. Population • Great Financial Center • The "Great Central Market" Food Producing and Processing Center • Leader in Iron and Steel Manufacturing • Good Labor Relations Record • 2,500,000 Kilowatts of Power • Tremendous Coal Reserves • Good Government • Good Living • Good Services for Tax Dollars.*

TERRITORIAL INFORMATION DEPARTMENT

Marquette Building—140 South Dearborn Street, Chicago 3, Illinois—Phone RAndolph 6-1617

COMMONWEALTH EDISON COMPANY • PUBLIC SERVICE COMPANY OF NORTHERN ILLINOIS
WESTERN UNITED GAS AND ELECTRIC COMPANY • ILLINOIS NORTHERN UTILITIES COMPANY

SPEED PRODUCTION WITH MIDLAND WELDING NUTS

U. S. PAT. No. 2054189

1/2" F-2012

5/8" F-2016-A

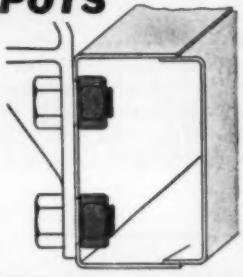
RAPID ASSEMBLY and accuracy are assured by the Midland Welding Nut because it is *self locating*. Collar on nut locates into pierced hole in receiving member. Eliminates use of locating pins or fixtures.

PARTICULARLY USEFUL IN "BLIND SPOTS"

The Midland Welding Nut in concealed and hard-to-reach places, as shown here, speeds up production materially.

Midland Welding Nuts offer numerous other time-saving and cost-saving advantages.

Write, wire or phone us for complete information.



The MIDLAND STEEL PRODUCTS CO.

6660 Mt. Elliott Avenue • Detroit 11, Michigan

WORLD'S LARGEST MANUFACTURERS OF AUTOMOBILE FRAMES—

Power YOUR PRODUCT WITH...

BARCOL MOTORS

- UNIDIRECTIONAL
- SYNCHRONOUS OR REVERSIBLE
- WITH OR WITHOUT GEAR REDUCTION
- UP TO 1/30 H.P.
- ENGINEERING SERVICE

for FANS, HAIR DRYERS, SPOT HEATERS, OIL BURNERS, DISPLAY TABLES, VENTILATORS, PROJECTORS, TOYS, PUMPS, VAPORIZERS, VENDING MACHINES, FACSIMILE RECORDERS

BARBER-COLMAN COMPANY ROCKFORD ILLINOIS

Hartford PRECISION BALLS

CHROME ALLOY • STAINLESS STEEL
BRONZE • MONEL • K-MONEL • ALUMINUM
PLASTICS • COPPER • GLASS • DRILLED BALLS

Precision balls for every industrial requirement. Made in many different materials. Send your specifications for recommendations from our Engineering Department.

THE HARTFORD STEEL BALL CO.
HARTFORD, CONN.

NEWARK N. J. OFFICE MARKET 2-7169 | EXPORT OFFICE PHONE PENNSYLVANIA 6-2078 | NEW YORK, CHICAGO OFFICE FRANKLIN 1977

Practical design methods and procedures actually used in engineering design departments

EVERY design engineer has always wished for a compilation of design standards and methods of design procedure. Many engineering departments have gathered material of this kind which they call their standards manual.

The Editors of **Product Engineering** from the very first issue of the magazine gathered, compiled, checked and edited such reference sheets.

Now, in this one practical book, they have brought them all together in authoritative form for the use of all design engineers.

HANDBOOK OF MECHANICAL DESIGN

By **GEORGE F. NORDENHOLT**
Editor of Product Engineering

JOSEPH KERR
Assistant to the Editor of Product Engineering

and **JOHN SASSO**
Formerly Managing Editor, Product Engineering

285 pages, 8 x 11, 555 illustrations, $5.00

A HANDY book of time-saving ideas and data for the designer of industrial machinery and equipment. Everything is boiled down to essentials and presented in concise, quick-use nomograms, charts, tables, check-lists, etc. Calculations, properties of materials, production factors of design, and similar material is well represented, and other chapters give a great many basic designs for fastenings, mechanisms, drives, controls, etc., readily adaptable to a wide number of applications. This is a book the engineer will use right at the drafting board, for quick, ready aid in scores of practical design problems.

Most of the book consists of material that has appeared in **Product Engineering**—special features of great popularity—here condensed, re-edited, and brought up to date, and brought together in convenient form.

Special Features

A special feature is a chapter by S. A. Kilpatrick, and O. J. Schaefer, of The Glen L. Martin Company, on stress calculations for thin aluminum sheet sections.

Other features are standard procedure in the design of springs, spring charts, methods for calulating belt drives, nomograms for engineering calculations, and the material on typical designs.

Over 500 illustrations are included, many of which are engineering drawings of design details with concise remarks on this distinctive features of use.

McGRAW-HILL
ON-APPROVAL COUPON

McGraw-Hill Book Company, Inc., 330 W. 42nd St., NYC 18, NY.
Send me Nordenholt, Kerr and Sasso's HANDBOOK OF MECHANICAL DESIGN for 10 days' examination on approval. In 10 days I will remit $5.00, plus few cents for delivery, or return the books. (We pay for delivery if you remit with this coupon; same return privilege.)

Name .....

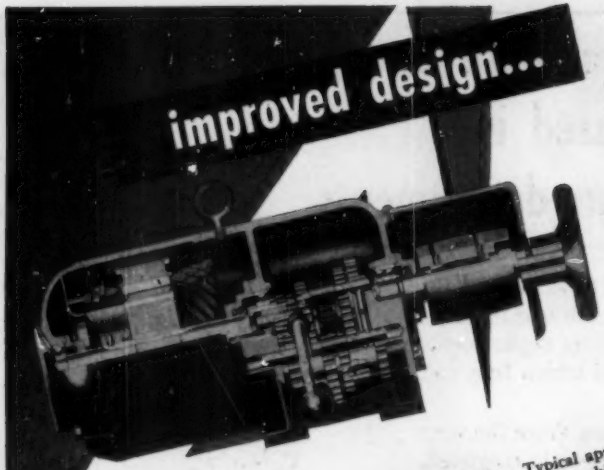
Address .....

City ..... Zone..... State.....

Company .....

Position PPE-2-50

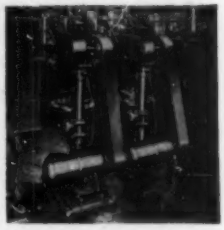
Books sent on approval in U. S. and Canada only.



● Today's high speed production schedules demand greater machine flexibility than ever before.

Lima Gearshift Drives, with their improved modern design, are increasing production and lowering operating costs in progressive plants throughout the world.

If you have a problem in machinery motorization, requiring selective speeds, there is a Lima Gearshift Drive to suit your needs. Factory representatives are in the field to serve you—write, wire or call for the address of the one in your vicinity.



Typical application of Lima Gearshift Drives to automatic tapping machines. Photo courtesy International Harvester Company.

LIMA

Representation in principal cities

GEARSHIFT DRIVES & MOTORS

THE LIMA ELECTRIC MOTOR CO. 2325 Findlay Road • Lima, Ohio

KOH-I-NOOR PRODUCTS

The RIGHT pencil for the RIGHT job

Famous for their outstanding characteristics. Whatever is required in pencil performance will be found in our singularly commendable quality lines.

If it's KOH-I-NOOR you can be sure.

DRAWING PENCILS
COPYING PENCILS
WRITING PENCILS
CHECKING PENCILS
COLORED PENCILS
OFFICE PENCILS
ART PENCILS
HOLDERS and LEADS
PENHOLDERS and ERASERS

Worlds change but KOH-I-NOOR quality remains.

KOH-I-NOOR

KOH-I-NOOR PENCIL COMPANY, INC., BLOOMSBURY, NEW JERSEY

Herbrand SINCE 1881

PRECISION

DROP FORGINGS

...any size or shape up to 200 lbs.

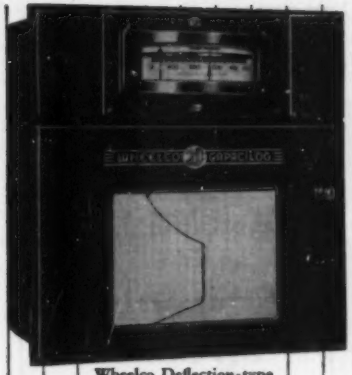
Herbrand DIVISION

THE BINGHAM-HERBRAND CORPORATION, FREMONT, OHIO

PRECISION DIE MADE—LOWEST POSSIBLE COST

DAYTON ROGERS MFG. CO.

Minneapolis 7, Minnesota



Wheelco Deflection-type Temperature Recorder

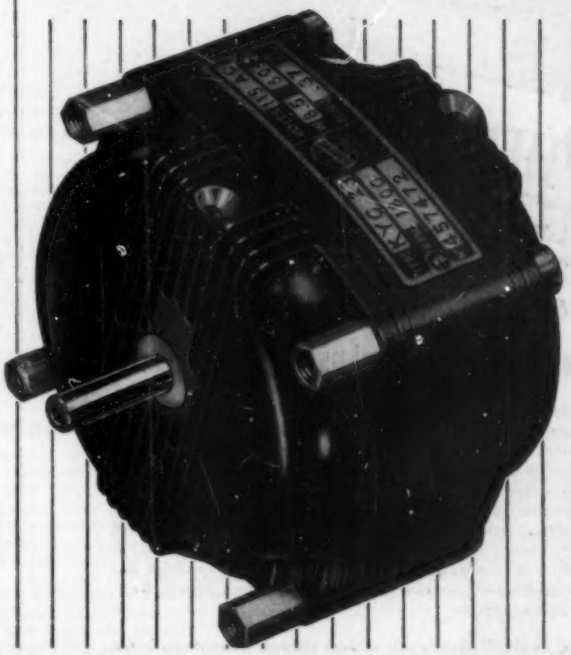
award-winning

temperature recorder uses a

Bodine Motor

The new Wheelco Deflection-type Temperature Recorder was recently judged one of the five outstanding designs of the year in the Eleventh Annual Product Design Competition conducted by Electrical Manufacturing Magazine. A Bodine Type K motor is used to position the follow-up arm and pen. This motor was selected because of its precise, reliable operation and rugged construction.

Bodine motors are built to meet high standards of performance and to provide trouble-free operation with a minimum of attention. Consult your nearest Bodine representative when designing a device which needs a fractional horsepower motor drive. Bodine Electric Company, 2260 West Ohio Street, Chicago 12, Illinois.



Bodine Type K motor. Only 2⅛ in. high. Especially adapted to use on instruments and controls. Normal 60-cycle output ranges from 1/2000 hp to 1/500 hp on continuous duty.

BODINE FRACTIONAL HORSEPOWER MOTORS

DISTRICT AGENTS

BUFFALO 3, N. Y.
Ellicott Square—S. E. Shea

CAMBRIDGE 39, MASS.
686 Massachusetts Ave.—W. A. Block

CLEVELAND 3, OHIO
4500 Euclid Ave.—W. R. Ufholman

DETROIT 1, MICHIGAN
6464 Cass Ave.—C. D. Miller

KANSAS CITY 6, MISSOURI
903 McGee Street—T. Pollmeuter

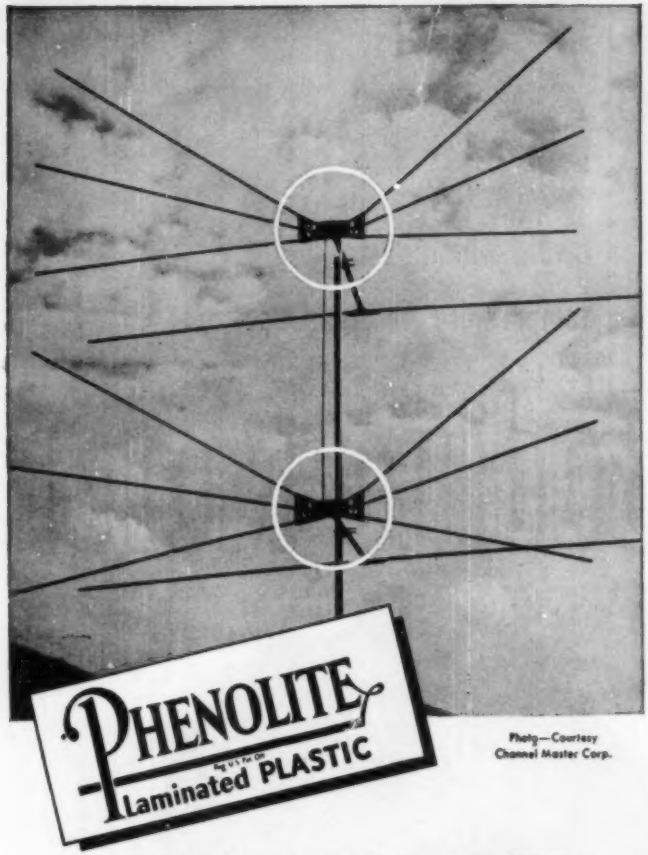
LOS ANGELES 13, CALIF.
411 So. Wall St.—H. M. Neil

MINNEAPOLIS 15, MINNESOTA
712 Sixth Ave., So.—A. C. Jacobson

NEW YORK 10, N. Y.
55 West 42nd St.—H. C. Meyerge

ROCHESTER 4, N. Y.
825 Commerce Bldg.—S. E. Shea

SAN FRANCISCO 3, CALIF.
995 Market St.—J. F. Cady



Photo—Courtesy Channel Master Corp.

the ideal material to insulate elements of Television Antennae

In the development of television, Phenolite has played a vital role as an insulating material in antennae, TV receivers and transmitting equipment. This is due to its excellent electrical properties coupled with its ease in machining. Its low power factor at ultra-high frequencies makes it especially valuable as television and radio insulation. Because of its low moisture absorption, any variation in electrical properties is negligible, even under long exposure to high humidity—hence its value in antennae insulation. Phenolite, in addition, is light in weight with excellent machining qualities, and one of the strongest materials per unit weight known. Sheets, Rods, Tubes, Special Shapes.

National Service Engineers will, without obligation, assist you in employing Phenolite, National Vulcanized Fibre and Peerless Insulation to your best advantage.

NATIONAL VULCANIZED FIBRE CO.
WILMINGTON DELAWARE
Offices in Principal Cities
Since 1873

ELECTRICAL WIRING *for* Motor Driven Machines

This 16-page article provides invaluable, fundamental information on power and control wiring details: design factors and installation requirements for efficient machine performance, trouble-free operation, and attractive appearance.

Written expressly to serve as reference material for design engineers, the text is clear and concise. Helpful photographs, diagrams, and schematic drawings supplement the text.

A few reprints of this article are available in booklet form at 25¢ each. Write to Reader Service Department.

•

PRODUCT ENGINEERING

330 W. 42ND STREET
NEW YORK 18, N. Y.

Standardize on Dependability

AUTOMATIC ELECTRIC

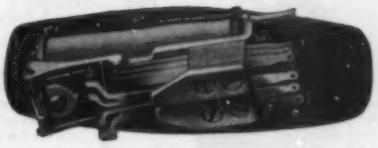
CHICAGO

RELAYS

In Automatic Electric's complete line of relays, there are over forty basic types—offering spring and coil combinations in almost infinite number. They are dependable and proved products of an organization that has made electrical remote control its business for more than fifty years.

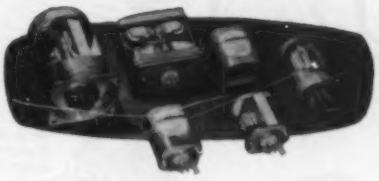
New Class "B" Relays

The newest and most outstanding member of Automatic Electric's relay family is the Class "B"—even better than the widely used, *widely copied* Class "A" Relay. Designed for ordinary relay service—opening, closing or switching circuits—and for extremely high-speed operation. Independently operating twin contacts assure perfect contact operation. Contact points are dome-shaped to maintain uniformly low contact resistance. May be arranged in one or two pileups with maximum of 16 contacts on 13 springs in each pile.



Hermetic Sealing Available To Maintain Automatic Electric Quality

All Automatic Electric Relays can be obtained in hermetically sealed housings to maintain the high quality for which these relays are famed. The "sealed-in" controlled atmosphere protects them from electrical or mechanical failure resulting from varying conditions of temperature, dust, humidity, acid, fungus or air pressure —and makes them completely tamperproof.



SWITCHES

Automatic Electric Stepping Switches are designed and built to assure exceptionally long life. A complete range of Automatic Electric Switches is available for all remote control applications.

The New Type 45 Switch

Here, for example, is a rotary switch that's new and better! *Faster* . . . 70 steps a second. *Greater capacity* . . . up to 10 (or more) 25-point bank levels, with single-ended wipers available for 50-point operation. *Simpler* . . . only one field adjustment.

Compact rotary and re-set type switches are also available with 10-point banks, levels and speeds of 35 steps a second for automatic or remote-control operations.

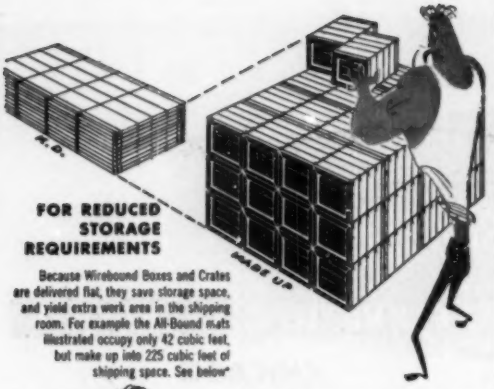
And there's the famous "Two-Motion Switch" that selects one circuit from among two hundred in just *2 seconds* or less. It's a re-set type switch adaptable to either automatic or remote control.

For help in the field of remote control, call in an Automatic Electric field engineer. Meanwhile, send for helpful literature. Address AUTOMATIC ELECTRIC SALES CORPORATION, Chicago 7, Ill. In Canada: Automatic Electric (Canada) Ltd., Toronto.

RELAYS SWITCHES

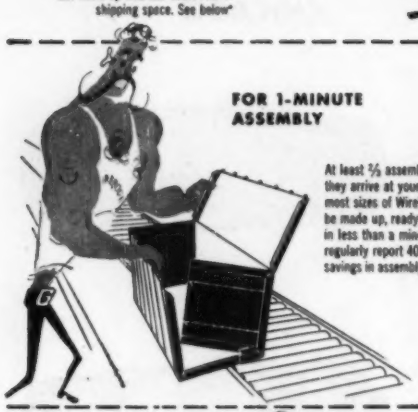
AUTOMATIC ELECTRIC

CHICAGO



FOR REDUCED STORAGE REQUIREMENTS

Because Wirebound Boxes and Crates are delivered flat, they save storage space, and yield extra work area in the shipping room. For example the All-Bound mats illustrated occupy only 42 cubic feet, but make up into 225 cubic feet of shipping space. See below*



FOR 1-MINUTE ASSEMBLY

At least ⅔ assembled when they arrive at your plant, most sizes of Wirebounds can be made up, ready to pack in less than a minute. Users regularly report 40-50% savings in assembly time.*

FOR BETTER, SAFER STACKING

The versatility of the Wirebound principle—the strength of steel combined with thinner wood—permits variation of wire gauges, staple spacing, battens and cleats to provide safe structural strength for large and small containers to meet all warehousing requirements. Note*

USE

Wirebound

BOXES & CRATES

FOR LOWER TOTAL SHIPPING COSTS

60 Wirebound Plants throughout the United States

***Send for this free book!** Explains in detail Wirebound principles, advantages, features and describes how Wirebounds are designed to suit every size and shape of product. Mail coupon today.*

Wirebound Box Manufacturers Assn., Room 1820, Borland Bldg., Chicago 3, Ill.

☐ Send Booklet of Product Information ☐ Send a Sales Engineer

NAME

COMPANY ADDRESS

CITY ZONE STATE

OUR PRODUCT IS

WHEN DISASTER STRIKES

The product
behind the man
behind the DISASTER
IN THE HEADLINES . . .

Every result has a cause—and when disaster strikes, we know that somewhere along the line there was a man who didn't think through to what might happen before it did happen.

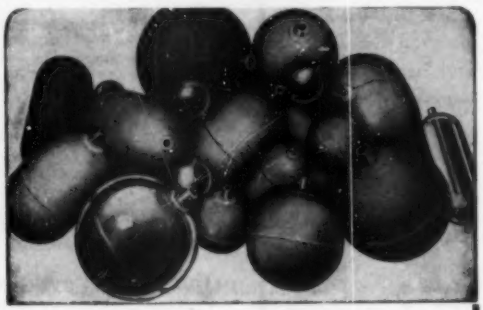
We remember this truism with a deep sense of responsibility when making Cash-Acme valves for industry.

And when our valves leave the factory en route to your plant, we know that so-far is so-good. You have selected a dependable product and gone far to guarantee the safety of human life and property entrusted to your judgment.

CASH-ACME
Automatic Valves

A·W CASH VALVE MANUFACTURING CORPORATION

6662 EAST WABASH AVENUE DECATUR, ILLINOIS, U. S. A.



Send for Nicholson

FLOAT BULLETIN 348

Complete Data on Welded Floats: Diagrams, Tables, Formulae for Calculation of Buoyancies

The booklet is a standard reference for specifiers of welded floats. Nicholson furnishes any type: for external or internal pressures; in stainless steel, Monel, chromium, cadmium or copper-plated steel. Sizes, 2" to 14" diam.; press. to 4800 lbs.; standard or special connections. 2-day delivery on many sizes and shapes. Nicholson floats are standard with hundreds of manufacturers.

W. H. NICHOLSON & CO. 200 OREGON ST. WILKES BARRE, PA.

You don't have to shop around... Allegheny Stainless is available in every form you may need

WHATEVER you want, it's available in Allegheny Metal—from the finest of wire to heavy plates, castings and forgings, including sheets, strip, bars, shapes, tubes—*everything!*

That's not only handy, but advantageous: one reliable source, one undivided responsibility, one well-known standard of quality and uniformity. Furthermore, we're steadily improving supply facilities—you can get Allegheny Metal promptly in any grade, form or finish.

When you're in the market, keep it in mind to specify Allegheny Metal, the pioneer stainless steel. And remember, wherever you use it, Allegheny Metal looks better, lasts longer, works out to be cheapest in the long run.

Complete technical and fabricating data—engineering help, too—yours for the asking.

ALLEGHENY LUDLUM STEEL CORPORATION

The Nation's Leading Producer of Stainless Steel in All Forms

AL

Pittsburgh, Penna. . . . Offices in Principal Cities

Allegheny Metal is stocked by all Jos. T. Ryerson & Son, Inc., Warehouses

NEW F-86A JET IS LEDEX EQUIPPED!

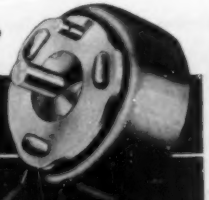
NORTH AMERICAN AVIATION Chose LEDEX *ROTARY* SOLENOIDS *for DEPENDABILITY!*

Humid tropics, sand-laden desert skies, frozen North or extremely high altitudes . . . the new Air Force North American F-86A Sabre Jet Fighter is prepared to defend our nation under *any* conditions. Ledex *Rotary* Solenoids play an important part in this *dependability*. Several vital mechanisms are remotely controlled and powered by Ledex *Rotary* Solenoids.

The same Ledex standard of dependable remote control and power is available for your product. The vast production applications of Ledex *Rotary* Solenoids vary from the dependable snap-action operation of aircraft mechanisms to the powerful actuation of rugged hydraulic valves in heavy duty materials handling equipment.

We supply to quantity users and solicit the opportunity to be of assistance in engineering a Ledex *Rotary* Solenoid to meet the requirements of your product.

Write today for LEDEX ROTARY SOLENOID BASIC ENGINEERING DATA



G. H. Leland INC.

160 WEBSTER STREET, DAYTON 2, OHIO

Recent Developments in

PLASTICS and RUBBER

New materials and their characteristics, processes and techniques, and applications developed since the war are reviewed in a 32-page report which appeared in the April 1947 issue of *Product Engineering*.

This valuable reference for design engineers summarizes working data on

Polytetrafluoroethylene
Modified Styrenes
Polyethylene
Vinyl Plastics
Plastics-Synthetic Rubber Combinations
Synthetic Rubber
Nylon
Silicones
Cellulosic Plastics
Thermoplastic Laminates
Honeycomb-Sandwich Structures
Protective Coatings

Reprints in pamphlet form available at 25¢ each from

Readers' Service Department

PRODUCT ENGINEERING

330 West 42nd Street
New York 18, N. Y.

Let this entire page represent the area of plain tube required for your heat transfer. The same heat transfer surface can be concentrated in relatively the space occupied by this block of type by using Wolverine *Trufin—the integral finned tube.

Send for literature

WOLVERINE TUBE DIVISION
CALUMET & HECLA CONSOLIDATED COPPER COMPANY
Manufacturers of seamless, non-ferrous tubing
1415 **CENTRAL AVENUE** • **DETROIT 9, MICH.**
Plants in Detroit, Mich. and Decatur, Ala.
*Reg. U. S. Pat. Off.

IT'S A FAR CRY
FROM HAND LOOMS
TO THE USE OF

MAGNESIUM DIE CASTINGS

IN THE

TEXTILE INDUSTRY

Yes — the fields into which the use of magnesium die castings can be applied are almost boundless. For example: The textile industry has learned that many production parts die cast from magnesium cut maintenance and replacement costs. The exceptional light weight of precision die cast magnesium, permits higher maximum speeds. Too, magnesium is exceptionally desirable for light-colored materials and yarns—it does not smudge.

There may be applications for aluminum or magnesium die castings that can help cut costs in your industry—either for use on your production line or for the actual substance of your product. Coupled with extreme light weight and high tensile strength, die castings eliminate many costly hours otherwise required for machining.

LITEMETAL DICAST, INC. is an organization of specialists—men thoroughly experienced in the casting and machining of magnesium and aluminum alloys—the new metals of structural design.

Write today for literature on Litemetal Dicasting.

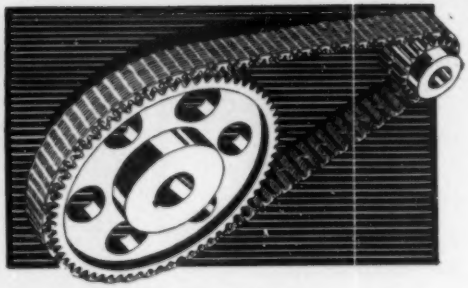
Quick action on Inquiries.

LITEMETAL DICAST Inc.

A DIVISION OF HAYES INDUSTRIES

1921 WILDWOOD AVE. · JACKSON, MICHIGAN

PLANT AND EXECUTIVE OFFICES

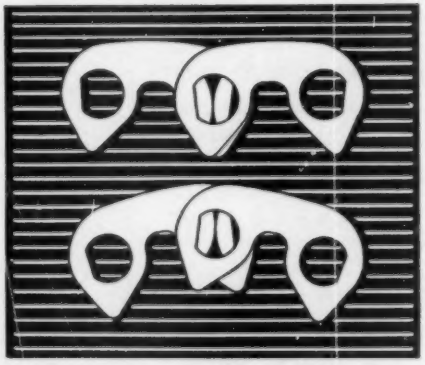


CHAIN DRIVES ARE NOT ALL ALIKE

Look at the JOINT STRUCTURE and see the difference

Alike in general appearance. Alike in interchangeability for operating on various makes of sprockets. But not alike in the joint—the heart of a silent chain. Look at the joint of a Ramsey Silent Chain and see immediately why it is different from all other silent chains. The Ramsey joint is designed on the roller bearing principle resulting in joint action that is practically friction free. A Ramsey chain, with this joint in every link, will operate at high speeds without heating and with no more lubrication than a roller bearing. This means maintenance cut to the bone, smooth operation of the machine being driven and long life to the chain drive. It will pay to investigate - - -

RAMSEY Silent Chain Drives

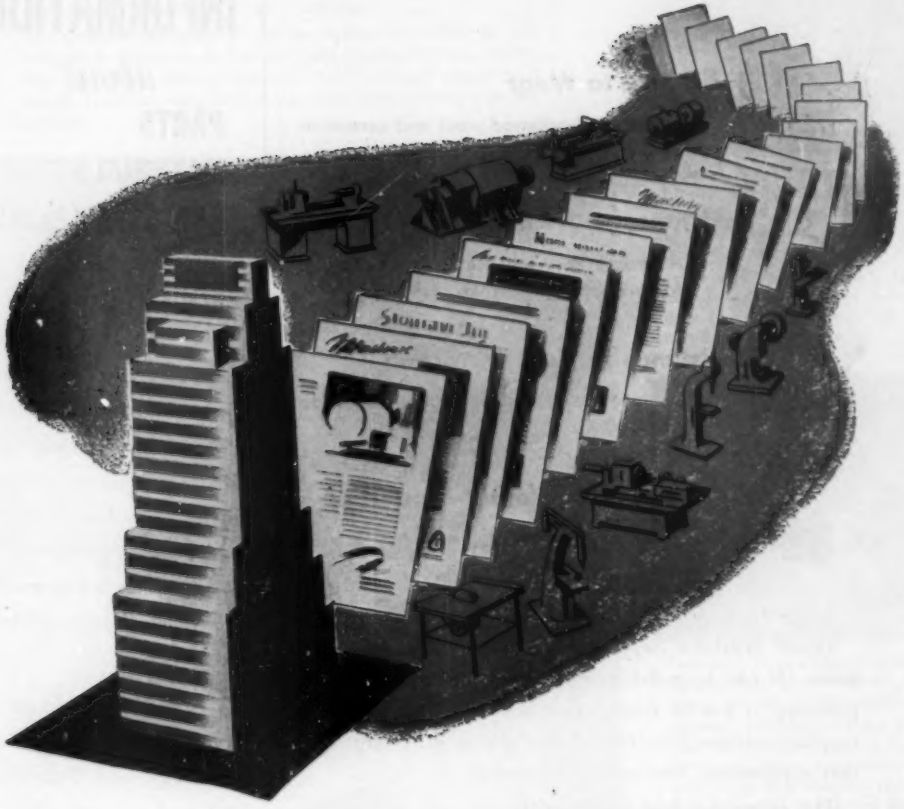


The RAMSEY ROLLER BEARING JOINT. See how the rolling action of the pins reduces friction to a minimum. Note the open construction that allows oil to penetrate and adhere to the working surfaces. Only a slight amount of oil is required. No oil bath necessary.

FREE—Our new Engineering Data Book No. 550. It's full of design information on Ramsey Chains and Sprockets and their application to all types of machines. Send for your copy today. Use your company letterhead.

RAMSEY CHAIN COMPANY, INC.

5051 BROADWAY **ALBANY, N. Y.**



The Parade that has no End

As you go through the pages of this magazine . . . or of any other McGraw-Hill publication . . . a colorful parade of advertising pages unfolds before your eyes.

If you are like thousands of other readers of these magazines, you'll become an avid spectator of this interesting educational show. You'll take in the *whole* of this passing parade.

Why? Because this parade is a non-stop exhibition of all that's new in industry—new developments in products and services, new ways for the buyer to make use of these products, news which can often mean the difference between profit and loss to you.

That's why readers of McGraw-Hill magazines are cover-to-cover readers. That's why they're *regular* readers . . . *serious* readers. That's why men say: FOR THE FACTS OF *INDUSTRIAL* LIFE, TURN TO McGRAW-HILL.

McGRAW-HILL

Publishing Company, Inc., 330 West 42nd Street, New York 18, N. Y.

SYNTHETIC SAPPHIRE *for*

Resistance to Wear

Outlasting hardened steel and cemented carbides 2 to 5,000 times.

Resistance to Friction

Affording very low friction surfaces due to hardness and surface continuity.

Resistance to Heat Distortion

Retention of form at temperatures up to 1,000°C.

Retention of Insulating Properties

Excellent dielectric properties over a wide range of temperatures.

LINDE Synthetic Sapphire is available in a variety of forms. It can be polished by flame or ordinary diamond polishing; it can be formed and bent by flame. Polished sapphire surfaces keep free of dirt, and in many anti-friction applications, need not be lubricated.

The experience that LINDE engineers have in applying sapphire to industrial processes may be of help to you. Call or write the LINDE office nearest you. Get your copy of the "Synthetic Sapphire Data Sheet", and the "Synthetic Crystal Stock List" of forms available.

Linde
Trade-Mark

THE LINDE AIR PRODUCTS COMPANY
Unit of Union Carbide and Carbon Corporation
30 East 42nd St., New York 17, N.Y. UCC Offices in Other Principal Cities
In Canada: DOMINION OXYGEN COMPANY, LIMITED, Toronto

The term "Linde" is a trade-mark of The Linde Air Products Company.

WANT MORE INFORMATION *about*
PARTS
MATERIALS
SUB-ASSEMBLIES
or
FINISHES?

Chances are you will always find in PRODUCT ENGINEERING's "New Catalogs and Bulletins" insert several listings offering literature which will supplement the articles and advertisements which are of greatest interest to you.

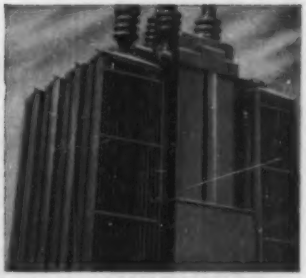
So, each month, be sure to check through the "New Catalogs and Bulletins" and send us your requests. Without cost to you, we'll see to it that the manufacturers concerned receive your requests promptly.

•

PRODUCT ENGINEERING
330 W. 42ND STREET
NEW YORK 18, N. Y.

Now this table loves wet glasses! The Problem: Furniture manufacturers wanted a way to keep wet glasses from ruining furniture finishes and leaving white rings.

The solution: Industrial Finish Engineers were called in. Developed a special finish that not only laughs off water stains, but also resists heat, abrasion, alcohol and food stains. As a result, furniture makers have an extra selling point—a better product.



Problem: Makers of electrical transformer boxes wanted a finish that would withstand heat of molten asphalt mixture used to anchor electrical elements in place.

Solution: Industrial Finish Engineers developed a finish that not only withstood this heat, but was also durable, good looking.

Problem: To find a finish that would protect cars from weather, corrosion, and be applied quickly.

Solution: Industrial Finish Engineers were called in. Developed a finish only three-thousands of an inch thick that resisted the elements — could be applied fast — dried fast—was durable.

Problem: To develop a colored coating to be applied to plastic articles.

Solution: Industrial Finish Engineers developed a special enamel finish. Manufacturers can now make a single run by coloring the plastic with the application of a new enamel in many colors.

Improve your sales through Engineered Industrial Finishes!

On this page are just a few examples of the way Industrial Finish Engineering can cut down manufacturing costs and improve the selling features of a product.

What can it do for your product? How much can it improve sales? How can it cut manufacturing costs?

To learn the answers, consult with an Industrial Finish Engineer.

For the Finish Industry has technical ability to make finishes equal to the purpose for which each product is bought. Remember, most of your customers *start buying with the finish in mind.*

The better the finish - The better the buy!

© 1950, National Paint, Varnish and Lacquer Association, Inc., Washington, D. C.

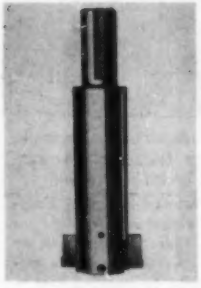
Designers!

If you have either of these assembly problems—

Write for our helpful booklet

1 Make it tight against vibration

An air impeller, for example. The fasteners are under *continual* vibration. A famous manufacturer of air-moving equipment (name on request) uses Bristol's Multiple-Spline Socket Set Screws because the multiple-spline socket permits tightening much further than possible with any other screw.



2 Make it easy to adjust

Boring bars, for example, where the cutting blade is adjusted by turning a screw. A well-known tool manufacturer (name on request) uses Bristol's Multiple-Spline Socket Set Screws because the tight set is easily broken by a flick of the wrench—with no spoiled screws.

Multiple-Spline and Hex Socket Screws . . . Cap and Set

BRISTOL'S
SOCKET SCREWS

Only BRISTOL gives you the right Socket Screw for every application

SEND FOR FREE SAMPLE AND BOOKLET, USING COUPON

THE BRISTOL COMPANY,
Mill Supply Division
121 Bristol Road, Waterbury 91, Conn.

Please send free sample of Bristol's Multiple-Spline Screw and bulletin showing applications to: Screw Sizes . . . . . .

NAME . . . . . .

COMPANY . . . . . .

ADDRESS . . . . . .

CITY . . . . . STATE . . . . . .

Engraving

Here is the most versatile machine...So simple to operate by unskilled labor.

PROFILING
VERTICAL
MILLING

NEW HERMES Engravo

This heavy duty bench type model covers a larger engraving area than any other machine of its kind.

NEW HERMES, Inc.

13-19 UNIVERSITY PL. • NEW YORK 3
World's Largest Manufacturer of Portable Engraving Machines

WILLIAMS
DROP-FORGINGS

ANY SHAPE - ANY MATERIAL - COMPLETE FACILITIES

Write for free Forging Data Folder . . . Helpful, Informative

J. H. WILLIAMS & CO., "The Drop-Forging People" BUFFALO 7, N. Y.

MATHEMATICS for ENGINEERS
By Raymond W. Dull

THIS book gives you the mathematics you need in the form you need it. It is concise yet complete, a book for reference or study, as you wish, covering every phase of mathematics you are likely to meet, from simple numeric computations, through integration and summation. It is the kind of book that you will use again and again for a long period of years.

Second Edition, 780 pages, illustrated, $5.50

SEE IT TEN DAYS FREE MAIL COUPON

McGraw-Hill Book Co., 330 W. 42 St., N. Y. 18

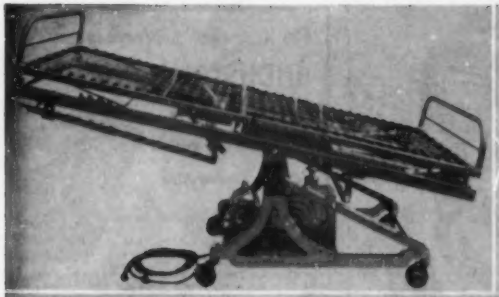
Send me Dull's MATHEMATICS FOR ENGINEERS for 10 days' examination on approval. In 10 days I will send you $5.50, plus few cents for delivery, or return the book. (We pay for delivery if you remit with this coupon; same return privilege.)

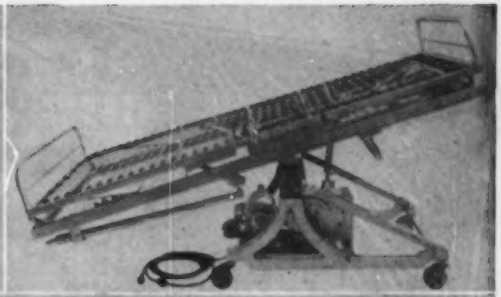
Name . . . . . .

Address . . . . . .

City . . . . . Zone . . . . . State . . . . . .

Company . . . . . Position PTE-2-50

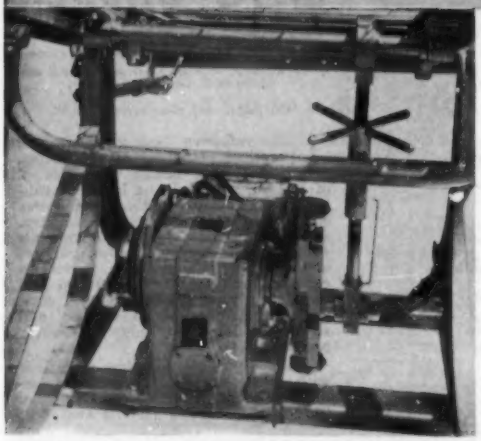




STOCK OHIO GEAR REDUCER

SETS THE PRESCRIBED SPEED FOR THE FAMOUS

ROCKING RESPIRATORY



The VASOSCILLATOR BED, pictured above is an accepted treatment for Buerger's Disease (hardening of the arteries). Tested for the treatment of polio and other vasculatory ailments, it is winning wide popularity among government institutions, hospitals and medical men all over the country. Its gentle, rocking motion provides patient comfort and aids materially in the treatment of respiratory diseases.

Obviously, the chief operating requirements are smoothness, quietness and thorough dependability. And the manufacturers found exactly these characteristics in a Stock D4 Ohio Gear Speed Reducer.

Further, in utilizing a stock unit they avoided the extra cost and time-consuming delays usually encountered when special units are specified.

You too, can save time, labor and expense by using Ohio Gear "Off the Shelf" service for the equipment you manufacture or use. Get in touch with our nearest distributor today and have him help with your power transmission problems.

THE OHIO GEAR COMPANY
1325 EAST 179th STREET • CLEVELAND 10, OHIO

DISTRIBUTORS AND REPRESENTATIVES

*Akron, Ohio
Hardware & Supply Co.
*Baltimore, Md.
L. A. Benson Co., Inc.
*Brooklyn 6, N. Y.
Northside Leather Belting Co., Inc.
Buffalo, N. Y.
F. E. Allen
*Buffalo, N. Y.
S. H. Pooley Belting Co.
Chicago 7, Illinois
Schrade-Batterson Co.
Dayton, Ohio
E. C. Hawk
*Detroit 6, Michigan
Eynon-Dakin Co.
Detroit 26, Mich.
George P. Coulter
*Erie, Pa.
Crossley Co.
*Findlay, Ohio
Bearing & Transmission Co.
*Grand Rapids, Mich.
F. Raniville Co.
*Hagerstown, Md.
Hagerstown Equipment Co.
*Indianapolis, Indiana
A. R. Young
*Kansas City, North, Mo.
Sesco Engineering & Supply Corp.
*Los Angeles, Calif.
J. W. Minder Chain & Gear Co.
Louisville 2, Ky.
Alfred Halliday
*Memphis 2, Tenn.
Memphis Bearing & Supply Co.
*Miami 9, Fla.
General Equipment & Supply, Inc.
*Minneapolis, Minn.
Industrial Supply Co.
*Muskegon, Mich.
Lake Shore Machinery & Supply Co.
*New Brunswick, N. J.
Slingman Industrial Supply Co.
*New Orleans 12, La.
R. J. Tricon Co.
*New Orleans 9, La.
Woodward Wight & Co.
*New York 12, N. Y.
Atlantic Gear Works
*New York 13, N. Y.
Patron Transmission Co., Inc.
*Paterson 4, N. J.
Bernstein Bros. Inc.
Pawtucket, Rhode Island
George G. Pragst
*Philadelphia 6, Pa.
Robert L. Latimer Co.
*Philadelphia 6, Pa.
Rothman Belting & Equipment Co.
*Piqua, Ohio
Bornell Supply Co., Inc.
*Pittsburgh, Pa.
Standard Machinists Supply Co.
*Portland, Oregon
J. W. Minder Chain & Gear Co.
*Rochester 4, N. Y.
H. M. Cross and Sons
*San Francisco, Calif.
The Adam Hill Co.
*St. Louis, Mo.
The Easmueller Co.
*Syracuse, N. Y.
U. and S., Inc.
*Toledo, Ohio
The Bearing & Transmission Co.

IN CANADA, *Montreal, Quebec, John Braidwood & Sons, Ltd.

*Stocks Carried.

ESTABLISHED 1915

OHIO GEARS

THIS WILL BE TRUE WHEN

COTO-COIL

FABRICATES THEM FOR YOUR PRODUCT

Our plant is modern and we keep our equipment modern to make sure that we produce the *best for the least.*

Thirty-one years of coil winding experience is yours for the asking, and our technical resources are such that we can co-operate on new or redesign work with your engineering department. When it's coils you need, call COTO-COIL.

BOBBINS

ACETATE INTERLEAVE
(Coalesced under W.E. Pats.)

PAPER INTERLEAVE

COTTON INTERWEAVE

TAPED FORM WOUND

UNIVERSAL SINGLE OR MULTI-PIE CROSS WOUND

COTO-COIL CO., INC.
COIL SPECIALISTS SINCE 1917
65 Pavilion Ave., Providence 5, R. I.

For low-cost performance of

INDUSTRIAL RUBBER PRODUCTS

. . . use these tested design techniques

Here's a handy reference that gives you a thorough analysis of the engineering, design, application, and maintenance principles you must take into account when working with rubber in industry. Whether you're an engineer—designer—shop superintendent—industrial technician—no matter what your link with the rubber field . . . you'll find this concise treatment of the physical and chemical properties of rubber compounds a handy and practical guide.

JUST PUBLISHED!

ENGINEERING WITH RUBBER

Edited by Walter E. Burton

In collaboration with engineers and research men of the B. F. Goodrich Company

461 pages, 445 illustrations, $6.50

THIS reference book gives you the practical **engineering, application, maintenance and design** principles of of molded, extruded and lathe-cut rubber, hose, gaskets, belting, and scores of other rubber parts used by industry. It illustrates uses for American-made rubbers, crude and reclaimed rubbers and rubber-like materials . . . presents a complete picture of the physical and chemical properties of rubber compounds, the typical dimensions and structural details of industrial rubber products.

It shows you how to reduce vibrations with rubber mountings—how to determine when extruded rubber parts can be used—how to use packing and sheet rubber, etc. Its tremendous store of useful information is ready to help you find the right answers, the first time, to your specialized design and construction problems.

Stage-by-stage procedures show you how:

- to select and use rubber adhesives
- latex parts can improve product design
- to engineer and install V-belt drives
- to select rubber linings to withstand chemical action
- to design and install conveyor belt systems
- to work and use hard rubber
- to specify correct types of rubber hose for best service
- lathe-cut rubber can reduce costs

SEE IT 10 DAYS' FREE

McGraw-Hill Book Co., Inc., 330 W. 42 St., NYC 18

Send me Burton's ENGINEERING WITH RUBBER for 10 days' examination on approval. In 10 days I will remit $6.50, plus few cents for delivery, or return the book. (We pay for delivery if you remit with this coupon; same return privilege.)

Name .....

Address .....

City ..... Zone..... State.....

Company .....

Position PPE-2-50

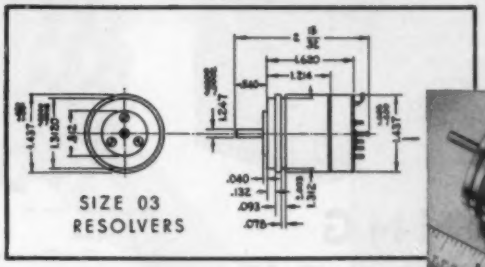
Announcing

NEW MINIATURE ELECTRICAL RESOLVERS
FOR COMPUTER PROBLEMS OF INDUSTRY

ARMA SIZE 03 (8 types)

KEY COMPONENTS IN ARMA'S POST-WAR TECHNIQUE OF ELECTRICAL "BRAIN BLOCK" INSTRUMENTATION

"Brain Block" instrumentation quickly describes any custom arrangement of light, small, accurate standard Arma components to make precision instruments and controls.



TYPICAL SPECIFICATIONS

SIZE	TYPE	DRAWING NUMBER	FREQ.	INPUTS	OUTPUTS	TRANSFORMATION RATIO (E/P)	PHASE SHIFT	INERTIA (oz. in²)	MAX. STATIC TORQUE (oz. in.)	WEIGHT (lbs.)	MAX. ANGULAR ERROR	MAX. AXIS MISALIGNMENT	REQUIRED TO ATTAIN TABULATED ACCURACIES			
													INPUT VOLTAGE	TEMPERATURE	AMPLIFIER DWG. NO.	AMPLIFIER WEIGHT (lbs.)
03	03JJ400	786832	400 ± 0.5	2	2	1.000 ± .0025	0° 0' ± 3.5'	0.05	0.5	.35	0.12% E_s†	± 7.0'	0.5 to 16.0	15° to 70° C	789640	1.2
03	03KK400	786833	400 ± 0.5	2	1	1.000 ± .0025	0° 0' ± 3.5'	0.05	0.5	.35	0.12% E_s†	± 7.0'	0.5 to 16.0	15° to 70° C	789640	1.2
03	03LL400	786834	400 ± 0.5	1	2	1.000 ± .0025	0° 0' ± 3.5'	0.05	0.5	.35	0.12% E*	± 7.0'	0.5 to 16.0	15° to 70° C	789640	1.2 Note #1
03	03MM400	786835	400 ± 0.5	1	1	1.000 ± .0025	0° 0' ± 3.5'	0.05	0.5	.35	0.12% E*	± 7.1'	0.5 to 16.0	15° to 70° C	789640	1.2 Note #1
03	03NN400	786836	400 ± 0.5	2	2	.955 ± .015	4° 30' ± 30'	0.05	0.5	.35	0.12% E_s†	± 7.0'	0.5 to 16.0	25° C	Not Required	
03	03PP400	786837	400 ± 0.5	2	1	.955 ± .015	4° 30' ± 30'	0.05	0.5	.35	0.12% E_s†	± 7.0'	0.5 to 16.0	25° C	Not Required	
03	03QQ400	786838	400 ± 0.5	1	2	.955 ± .015	4° 30' ± 30'	0.05	0.5	.35	0.12% E*	± 7.0'	0.5 to 16.0	25° C	Not Required	
03	03RR400	786839	400 ± 0.5	1	1	.955 ± .015	4° 30' ± 30'	0.05	0.5	.35	0.12% E*	± 7.0'	0.5 to 16.0	25° C	Not Required	

Deviations shown are maximum. Average deviation is much less. Quadratures and harmonics each never exceed 0.1% of the sum of the input voltages. Characteristics shown are attainable with indicated required auxiliary equipment and good engineering practices for precision circuits. Note #1. One amplifier may be used with two resolvers of this type.

*E = Input
†E_s = Sum of Inputs

These are the resolvers about which management men have been reading: "One of the means by which the many fast changing variables of industry can be coordinated and electrically translated is Arma's electrical resolver . . . the "brain block" that replaced a formidable aggregation of gears and slides previously used to solve the trigonometric functions. It is used in instrumentation involving computers and action-triggering circuits. And, resolvers come off Arma production lines accurate to a degree seldom equalled outside the precision model shop. They fit interchangeably into instrument assemblies."

RESOLVER CATALOG JUST PRINTED GIVES COMPLETE DETAILS ASK FOR A COPY

ARMA CORPORATION

254 36th STREET, BROOKLYN 32, N. Y.

SUBSIDIARY OF AMERICAN BOSCH CORPORATION

ARMA PRODUCTS RELEASED FOR PRIVATE INDUSTRY

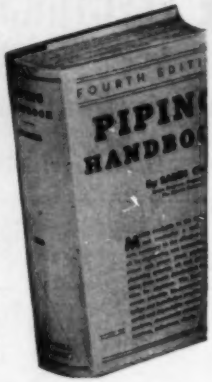
ARMA ELECTRICAL RESOLVERS* • ARMA SYNCHRON • ARMA INDUCTION MOTORS • ARMA INDUCTION GENERATORS • ARMA MECHANICAL DIFFERENTIALS • ARMA ALTERNATING VOLTAGE COMPARATOR • COMPUTING MECHANISMS • INDUSTRIAL CONTROLS • STABILIZATION DEVICES • NAVIGATIONAL EQUIPMENT • LIMITRON AUTOMATIC INSPECTION SYSTEM

* Licensed for use under Arma patents Nos. 2,465,504 and 2,467,646. License information available.

QUALITY ARMA INSTRUMENT PRECISION

Complete, comprehensive guide to piping design and application

—The data and methods you need for solving every piping problem



HERE is an indispensable tool for the engineer, contractor, and designer, the famous PIPING HANDBOOK. This vast compilation of data and methods for most effective use of piping puts at your fingertips all the principles that influence the design, construction and use of piping systems. *Any* fact, on any phase of piping practice, is here in clear, dependable, accessible form.

PIPING HANDBOOK

Fourth Edition

By SABIN CROCKER

Senior Engineer, Engineering Division, The Detroit Edison Company

1376 pages, 4½ x 7½, 334 illustrations, 329 tables, $7.50

Solve your piping problems with the help of this practical handbook packed with piping fundamentals, materials and techniques . . . and authoritative information you need on codes, dimensional standards, materials specifications, construction details, cost estimating, etc. It shows you the best types of apparatus for each job . . . brings you scores of methods for using equipment for best results, helpful analyses of the details of each job, easy-to-follow explanations of every phase of piping from start to finish.

Covers these piping fields

- Steam Power-plant Piping
- Building heating
- Plumbing
- Underground Steam Piping
- Water-supply Piping
- Fire-protection Piping
- Oil and Refinery Piping
- Gas Manufacture and Distribution
- Refrigeration
- Hydraulic Power Transmission

SEE IT 10 DAYS FREE

Look over this handbook at your leisure; note its wealth of helpful diagrams, curves, flow sheets, tables and photographs . . . its practical and accurate solutions of everyday problems. Return of the coupon below brings you a copy for FREE EXAMINATION. Send for it today.

McGRAW-HILL ON-APPROVAL COUPON

McGRAW-HILL BOOK CO., 330 W. 42 Street, New York, 18

Send me Crocker's PIPING HANDBOOK for 10 days' examination on approval. In 10 days I will send $7.50 plus few cents for delivery, or return book. We pay for delivery if you remit with this coupon; same return privilege.

Name .....

Address .....

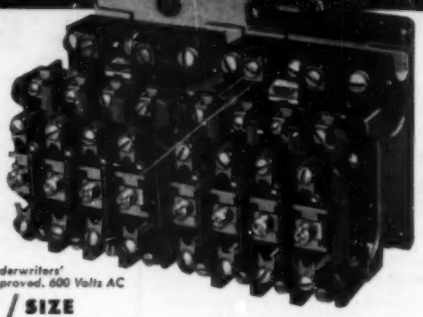
City ..... Zone..... State.....

Company .....

Position ..... FPE 2-50

Books sent on approval in U. S. and Canada only.

✓ Check R-B-M INDUSTRIAL CONTACTORS NOW!



Underwriters' Approved. 600 Volts AC

✓ **SIZE**

Non-Reversing

2 to 4 Pole 2-3/4" w. x 3-5/8" h. x 3-5/16" d.
5 to 8 Pole 5-9/16" w. x 3-5/8" h. x 3-5/16" d.

Reversing

2 to 4 Pole 5-9/16" w. x 3-5/8" h. x 3-5/16" d.

Note: 10 and 15 ampere contactors have same mounting and overall dimensions.

✓ **ACCESSIBILITY**

To replace contacts, it is not necessary to disassemble the complete contactor. Just remove the parts comprising the stationary and movable contacts. Contacts can be replaced without disturbing wiring. To change coil, remove magnet frame and coil assembly only. (See illustration below.)

✓ **FLEXIBILITY**

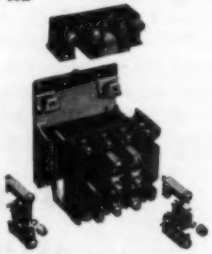
Using a screw driver only, you can easily change any pole from normally open to normally closed. No special parts required. 10 and 15 ampere parts are interchangeable.

✓ **RELIABILITY**

Laboratory tests involving millions of operations, plus field service of thousands of R-B-M contactors on door operators, radio transmitters, packaging and weighing machinery, hoists, machine tools and many other industrial applications offer proof of dependable, trouble-free performance.

✓ **ADVANCED DESIGN**

Melamine Insulation. Molded coil housing. Ilsco solderless connectors. 50/60 magnet coils. Palladium silver contacts. Stainless steel self-contained contact springs.



Where space is a factor, and accessibility a must—use R-B-M industrial contactors. Initial low cost plus dependable performance will save you money. Write for Bulletin 600 and price list on your company letterhead.

Dept. C-2 R-B-M DIVISION OF ESSEX WIRE CORP.
Logansport, Indiana

It's an "open and shut" case for flexible connectors

This tire re-capping machine opens and closes all day long. American Seamless Flexible Metal Tubing carries the hot steam in and out under pressure—safely, dependably, despite repeated flexing.

It's another example of how American Seamless Flexible Metal Tubing meets every requirement of the ideal flexible connector:

Seamless; leakproof
Pressure-resistant
Fatigue-resistant
Easy to connect

American Bronze Seamless Tubing carries steam to and from this automobile tire re-capping machine made by James C. Heintz & Company, Inc., Cleveland, O.

American Seamless Flexible Metal Tubing and American Flexible Metal Hose are made in a wide variety of styles and metals for conveying liquids, many chemicals, gases and semi-solids, under severe conditions of temperature, pressure and mechanical stress ... for protecting wiring and flexible driveshafts ... for connecting misaligned piping or ports.

If your equipment requires movable connectors, let us send you the complete story on American Flexible Metal Hose and Tubing, or let our Technical Department make recommendations. Write to The American Brass Company, American Metal Hose Branch, Waterbury 20, Connecticut. In Canada, The Canadian Fairbanks-Morse Co., Ltd.

ANACONDA

wherever connectors must move... American

FLEXIBLE METAL HOSE AND TUBING

Want to cut your production costs?

You'll find many ways to do it just by visiting the Tool Engineers'

INDUSTRIAL *Cost-Cutting* EXPOSITION

APRIL 10-14 (inclusive) PHILADELPHIA, PA.

TO SAVE YOUR TIME ON ARRIVAL AT THE EXPOSITION, JUST FILL IN COUPON BELOW AND MAIL

AMERICAN SOCIETY OF TOOL ENGINEERS

10700 PURITAN AVE., DETROIT 21, MICH.

Please mail me an advance registration form for the Industrial Cost-Cutting Exposition.

Name_____ Title_____ Company_____ Address_____

Did you know?

WESTERN UNION
MINIATURE PRECISION BEARINGS INC
KEENE NEW HAMPSHIRE
BEARINGS HAVE PROVEN SATISFACTORY
IN TEST OF OVER 50,000,000 CYCLES
ALL OTHER METHODS HAVE FAILED

Bearings shown actual size

50,000,000 Cycles . . . !

For applications where you can't afford to fail . . MINIATURE PRECISION BEARINGS manufactures over 50 different types and sizes of miniature ball bearings.

Catalog in Sweet's PD File or mailed immediately on request.

MPB MINIATURE *Precision* BEARINGS
INCORPORATED
KEENE, NEW HAMPSHIRE U.S.A.

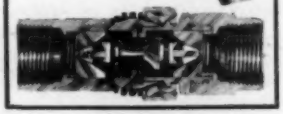
WHEN YOU . . .

Disconnect, You Stop the Flow in *Both* Ends

Wherever the flow of air, fluids, or gases must be interruped, Wiggins *INST-O-MATIC* couplings are lowering costs. Uncouple a Wiggins. You've automatically stopped the flow in both ends. Connecting, or disconnecting, is as simple as switching on a light. Wiggins *INST-O-MATIC* couplings can increase efficiency in your plant today, and lower costs.

EQUIPMENT MANUFACTURERS

Users' experiences prove conclusively that this design stands up longer under extreme pressure and vibration, and rarely requires replacement. Inquire today.

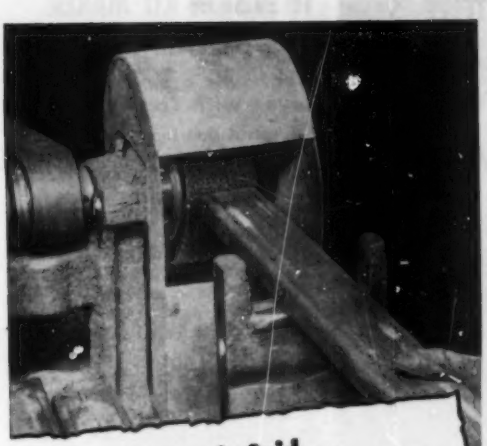


BASIC SIZES: ⅛", ¼", ⅜", ½"; also intermediate sizes where needed. Unconditionally guaranteed to be leak proof from 0 to maximum recommended pressure.

Wiggins

For proof of performance, write for name of nearest representative. E. B. WIGGINS OIL TOOL CO., INC., 3424 E. Olympic Blvd., Los Angeles 23, Calif.

QUICK DISCONNECT
INST-O-MATIC COUPLINGS



National Electric Said...
"*Make it* STIFF! TOUGH! RUGGED!"

When National Electric Products Corp. put their brushing problems in the lap of Pittsburgh's skilled brush engineers, they requested a special brush for rough duty. It had to be **stiff** enough to remove burrs and scales... **tough** enough to penetrate and clean... **rugged** enough to stand up under heavy operation at high speed.

Pittsburgh engineers came up with the right answer in a special power driven brush that met each National Electric specification . . . also increased plant efficiency and stepped up production.

You Can Depend on "PITTSBURGH" to Solve Your Brush Problems

We have brushes of all types in the complete Pittsburgh line which should comply with your specific needs . . . whether you're in glass, steel or plastics . . . in paper, tires, shoes or automobiles . . . because there's a Pittsburgh brush for every industrial use.

But if you have special problems, our staff of skilled brush engineers will be glad to design and build any type of power-driven brush to meet your particular specifications. What's more, they'll do it quickly, efficiently and economically.

Write or telephone PITTSBURGH PLATE GLASS COMPANY, *Brush Division*, Dept. W-2, 3221 Frederick Avenue, Baltimore 29, Md., for information . . . or tell us what your problem is, and let one of our engineers solve it for you. No obligation.

PITTSBURGH
Power Driven
BRUSHES

BRUSHES • PAINT • GLASS • CHEMICALS • PLASTICS
PITTSBURGH PLATE GLASS COMPANY

PRODUCT ENGINEERS!

Check this valuable new reference on . . .

The DESIGN and PERFORMANCE of SHAFT BEARINGS

THIS new book, includes the latest developments and procedures in bearing analysis and lubrication. It discusses, first, the general principles of bearing load analysis, introducing dimensional analysis in order to generaiize the results of bearing load computations. It then takes up the principles and problems of hydrodynamic lubrication . . . discusses rolling contact bearings . . . and considers the many variables of importance in boundary lubrication. A final chapter describes a representative group of bearing test machines. Throughout the book, the external conditions imposed upon representative shaft bearings have been considered in detail and integrated with lubrication theory.

Just Published!

ANALYSIS and LUBRICATION of BEARINGS

By

Milton C. Shaw, *Dept. of Mech. Eng., M.I.T.*

and

E. Fred Macks, *Lewis Flight Propulsion Laboratory, N.A.C.A.*

618 pages, illustrated, $10.00

This new book's analysis of shaft bearings is divided, roughly, into external and internal phases. It considers the bearing in relation to its position in the mechanism, and studies the conditions imposed on the bearing by its surroundings. Attention is directed to the manner in which the bearing supports the applied load. Common practices used in the design of bearings are treated fully. The book discards those practices contrary to fundamental concepts, suggesting more logical criteria, and points the way to rational design procedures based upon sound principles and the results of controlled experiments.

A few outstanding features

- Considers the dynamic aspects of lubrication
- Covers new developments in the theory of boundary lubrication and dry friction
- Discusses new bearing materials and lubricants
- Analyzes recently developed bearing types and arrangements
- Takes up such topics as high speed bearing stability, bearing erosion and limitations of present hydrodynamic bearing theory at high speeds

SEE THIS BOOK 10 DAYS FREE
Mail coupon today

McGraw-Hill Book Co., 330 W. 42d St., N. Y. C. 18

Send me a Shaw and Macks' ANALYSIS AND LUBRICATION OF BEARINGS for 10 days' examination on approval. In 10 days I will remit $10.00, plus a few cents for delivery, or return the book postpaid. (We pay for delivery if you remit with this coupon; same return privilege.)

Name .....

Address .....

City ..... Zone..... State.....

Company .....

Position PPE-2-50

This offer applies to U.S. only

TELEVISION KIT MAKER USES PRINTED TAPE

Electronic assembly keyed with Topflight

Electrovision, Inc. of New Rochelle New York, pioneer in the field of home built television sets, have found Topflight printed, pressure-sensitive, cellulose tape ideal for their merchandising needs.

Producers of Transvision television kits, Electrovision provides an assembly diagram with each kit, and each part of the kit, each lead, each terminal is numbered with a tab of Topflight Tape.

Instructions stickers

Some of the component parts require special instructions, others carry warning notices. All are quickly applied as each unit is packaged. Point of sale strips for use in retail outlets are also produced by Topflight.

Here, H. D. Suessholtz, president of Electrovision, Inc., applies a label to the chassis of a television kit to demonstrate the ease of application and his endorsement of Topflight.

TOPFLIGHT TAPE COMPANY

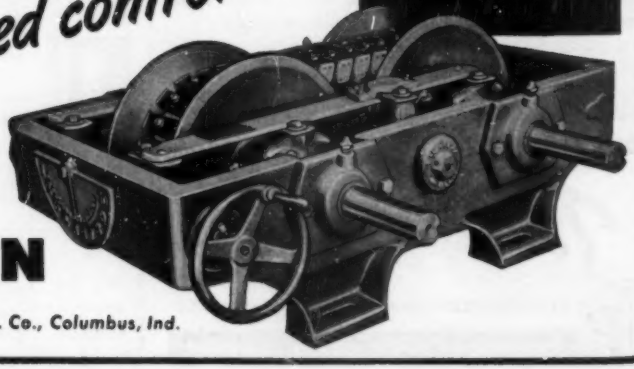
YORK PENNA.

Accurate Machine Control starts with an accurate transmission

To solve your speed-control problems

Look to the pioneer in speed control

World-famous Variable-Speed
TRANSMISSIONS
MOTOR PULLEYS
AUTOMATIC CONTROLS
ELECTRIC CONTROLS
REMOTE CONTROLS



Look to

LEWELLEN

Wire, phone or write Lewellen Mfg. Co., Columbus, Ind.

THIS MAN WOULDN'T NEGLECT

A MACHINE IN HIS PLANT

...yet he hasn't had a Chest X-Ray!

He checks every piece of mechanical equipment he owns for wear, lubrication, efficiency.

Yet he fails to take the simple precaution of a Chest X-Ray to make sure he does not have tuberculosis. *Not because he's opposed to the X-Ray. Simply because he is not sufficiently informed—or just hasn't taken the time and trouble, or does not realize the seriousness of the problem.*

A Chest X-Ray is the first step toward detecting tuberculosis in its early stages. And in its early stages it can be cured with the least loss of time from work.

So, if you're the man above, that one simple reason should make you get your Chest X-Ray—*today*. But listen, see how serious this really is:

Between the ages of 15 and 34, tuberculosis leads all other diseases as a cause of death—although at no age are you safe from TB. Yet, if everyone does his part by getting a Chest X-Ray periodically, and the majority of cases thus discovered are followed up, we can eliminate TB entirely as a public health hazard!

Will you do your part today? Get a Chest X-Ray. It may mean your life!

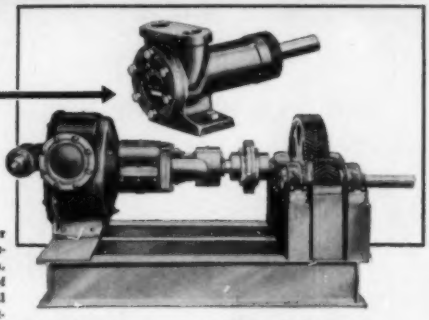
A PUBLIC SERVICE PROJECT — THE ADVERTISING COUNCIL

Published in the public interest by:

McGRAW-HILL PUBLICATIONS

VIKING *Rotary* PUMPS

Range
FROM ½ GPM
TO 1050 GPM



If your problem is to deliver a clean liquid in any capacity from ½ to 1050 gpm, check the complete line of Viking rotary pumps. All are self-priming, non-pulsating and capable of delivering against pressures to 100 psi (300 psi in heavy-duty styles—500 psi on hydraulic oils.)

The complete capacity range is available in either standard or special construction to meet your requirements.

Pumps are built to handle any liquid ranging in viscosity from L-P gas to grease. Check your requirements in Bulletin 505X. Send for your free copy today.

VIKING
AN HONORED NAME IN PUMPING

See Our Catalog In SWEETS

Viking PUMP COMPANY
Cedar Falls, Iowa

It's got what you want.

"SPECIFICATION" CUSTOM KILN DRIED WOOD

DRIED BY EXPERTS TO MEET YOUR MOST EXACTING MATERIAL SPECIFICATIONS

is production material (wood) at its best

To Meet TECHNICAL & AIRCRAFT Specifications and FOR ANY CUSTOM KILN DRYING up to 50' lengths

★ ★ ★ ★ ★

5 Automatic Cross Circulating Kilns
Operated by Experienced, Trained Kiln Engineers

Our Eastern customers, you may be sure, came to us for reasons profitable to them and remain for these and other advantages that have developed. Besides Specification Kiln Drying, always a main reason, there is the advantage of drying here where many of the leading woods originate — then cutting to pattern, finishing and delivery direct to user, saving extra handling. Then freight shipments of kiln dry weight against green result in another definite savings. It costs nothing to talk with us.

LUMBER MANUFACTURERS Inc.
2530 S.E. STEELE ST. PORTLAND 2, OREGON

Cable Address: Lumac
Long Distance—SU 1101
for Gordon Wilkinson, Pres.

There's a girl in our office...

. . . Whose one job is to expedite delivery of your requests for "New Catalogs and Bulletins" to the manufacturers concerned.

The job keeps her busy, too. She handles several thousand requests from PRODUCT ENGINEERING readers every month. And she's anxious to be of service to you whenever she can.

So check the "New Catalogs and Bulletins" insert if you haven't already done so. You'll find a lot of useful information listed there . . . and any of it is available to you promptly and without cost.

PRODUCT ENGINEERING

PROFESSIONAL SERVICES

THE CARLSON COMPANY
Spring Design Specialists
MECHANICAL PRODUCT DEVELOPMENT
277 Broadway — New York 7, N. Y.
Barclay 7-2552

T. F. ESERKALN
Engineering Consultant
Machine Design, Control Hydraulics, Product Development, Production Problems
2350 North Sixty-Second St. — Phone
Milwaukee 13, Wisconsin — Glenview 2-4390

HERMAN LEWIS GORDON
Registered Patent Attorney
Patent Investigations and Opinions
Warner Building — 100 Normandy Drive
Washington 4, D. C. — Silver Springs, Md.
National 3497 — SHepherd 2432

GEORGE H. KENDALL
Consulting Mechanical Engineer
Cost Reduction Studies: Process or Product.
Redesign Existing Products for Greater Profit.
Trouble Shooting Production, Design, Cost Problems.
Specialists Automatic Machinery, Processes, Controls.
New Developments, Patent Studies, Investigations.
New Products & Process Engineering Studies
P. O. Box 72 (Est. 1923) — Tel. Darien 5-1504
Noroton Heights — Darien, Connecticut

NEW YORK TESTING LABORATORIES, INC.
CHEMICAL, MECHANICAL, ELECTRICAL METALLURGICAL ENGINEERS
ANALYTICAL CHEMISTS, PHYSICISTS, X-RAY
Analysis, Tests of all Materials and Products. Plant and Field Services in Special Measurements of Stress, Sound, Vibration and other. Consultants in Litigation and Process Engineering and Design.
80 Washington St. — New York City 6, N. Y.

CHARLES VESELY & ASSOCIATES, INC.
Industrial Designers and Engineers
Design Engineering Product Development — Consumers Products Commercial Equipment Capital or Durable Goods
Office:
197-N. 123rd Street, Mem. ASME — Wauwatosa 13, Wisc. Mem. AIIE

The Consulting Engineer

By reason of special training, wide experience and tested ability, coupled with professional integrity, brings to his client detached engineering and economic advice that rises above local limitations and encompasses the availability of all modern developments in the fields where he practices as an expert.

REPLIES (Box No.): Address to office nearest you
NEW YORK: 330 W. 42nd St. (18)
CHICAGO: 520 N. Michigan Ave. (11)
SAN FRANCISCO: 68 Post St. (4)

POSITION VACANT

WANTED—CREATIVE Engineer with broad experience to design and build special purpose machines in progressive New Hampshire plant employing 65. Write giving experience and wages desired. P-2103, Product Engineering.

SELLING OPPORTUNITY OFFERED

ENGINEERING SALES Representative wanted in principal cities to handle complete, quality line of air and hydraulic cylinders. Write in confidence stating lines now being handled, territory covered and references. Leeden Mfg. Co., 1600 S. San Pedro St., Los Angeles 15, Calif.

EMPLOYMENT SERVICE

SALARIED POSITIONS $3,500-$25,000. If you are considering a new connection communicate with the undersigned. We offer the original personal employment service (40 years recognized standing and reputation). The procedure, of highest ethical standards, is individualized to your personal requirements and develops overtures without initiative on your part. Your identity covered and present position protected. Send only name and address for details. R. W. Bixby, Inc., 268 Dun Bldg., Buffalo 2, N. Y.

SALARIED PERSONNEL $3,000-$25,000. This confidential service, established 1927, is geared to needs of high grade men who seek a change of connection under conditions assuring, if employed, full protection to present position. Send name and address only for details. Personal consultation invited. Jira Thayer Jennings, Dept. R, 241, Orange St., New Haven, Conn.

POSITIONS WANTED

EXECUTIVE ENGINEER, 51, with proven ability in directing the activities of research, development, design and other engineering groups. Established record with manufacture of tractors, farm implements, automotive accessories, air conditioning, machine tools and special machinery. PW-1628, Product Engineering.

MECHANICAL ENGINEER, Design, development new products, steel and aluminum. Knows manufacturing processes and costs. 20 yrs. experience. Capable Executive. Excellent sales record. PW-1596, Product Engineering.

ENGINEER INVENTOR with 12 years Electro-mechanical experience at G. E. Co. in all phases design and manufacture. Licensed P.E. —Commercial pilot. Enthusiastic about results. Authority not mandatory. Open to suggestions. PW-2021, Product Engineering.

MECHANICAL ENGINEER: Member of A.S.M.E.; age 43; married; Registered Graduate Engineer, now employed, desires change for a more responsible position as Mechanical or Assistant Chief Engineer. Twenty years of diversified mechanical experience involving Design, Testing, Patent Development, Inspection, and Administration Duties. Will travel if necessary. Address PW-2112, Product Engineering.

NEW ADVERTISEMENTS

Copy received by February 20th will appear in the March issue.

TRANSPARENT PLASTIC MODELS
for
New product pilot working models
Polarized light stress analysis
Sales demonstration working models
Send prints for estimates
W. A. Haines, Box 371, Troy, Ohio

INSTRUMENT MANUFACTURERS
A Proportional divider having independently adjustable ends is now available on a non-exclusive licensing basis.
Patent #2467481
JOHN KURMER
4000 N. 43rd St. — Phila., 40, Pa.

MACHINE DESIGNERS

Established Mid-Western hydraulic machinery builder wants engineers experienced in designing heavy production machinery and hydraulic pumps, valves and controls. Thorough knowledge of metal working presses, plastics molding machines, die casting machines and hydraulic power equipment desirable. Do not apply unless you have over five years experience in these specific fields. Write giving experience and salary desired. All replies confidential.

P-1918, Product Engineering
330 W. 42nd St., New York 18, N. Y.

PRODUCT DESIGNER

For temporary position (6 months). Opportunity for permanency if exceptional. Must be graduate of accredited college with at least three years of product design experience. Only highly intelligent, aggressive applicants need apply. This is a well-paying excellent opportunity with a major midwest manufacturing concern. State education, experience, present salary, and salary requirement in first reply.

P-2062, Product Engineering
520 No. Michigan Ave., Chicago 11, Ill.

WANTED MECHANICAL ENGINEER

with knowledge of storage battery manufacture. Location small Midwestern town—Replies confidential.

P-1949, Product Engineering
520 N. Michigan Ave., Chicago 11, Ill.

WANTED—MECHANICAL ENGINEERS

For Research and Development work on Chemical Process Equipment and Scientific Instruments. One Senior Engineer with advanced degree and experience required to take charge of important project. Junior Engineers required for assistants. These are permanent positions for engineers of exceptional ability and inventiveness. Salaries open.

The Sharples Corporation Research Laboratories,
424 West Fourth Street, Bridgeport, Pennsylvania

EXECUTIVES
Interested in Changing Positions

Make use of our continuous nationwide contacts. We offer a unique, confidential & discreet service to Executives desiring to contact employers. Write for details.

Mutual Positions Plan Association
56 William Street — New York 5, N. Y.
(A Mutual, Non-Profit Membership Organization)

Engineers - Executives - Technical Men

Salaried Positions, $4,000 to $30,000. This Confidential service for men who desire a new connection, will develop and conduct preliminary negotiations without risk to present position. Send name and address for details.

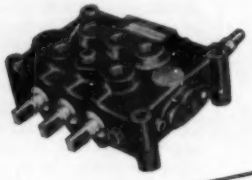
TOMSETT ASSOCIATES
1206-2 Berger Bldg., Pittsburgh 19, Pa.

OIL-HYDRAULIC PUMPS • VALVES • CYLINDERS

Look to HYDRECO *for* ALL THREE!

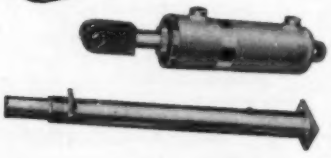
PUMPS

Five basic sizes, from 2¼ GPM to 130 GPM at pressure up to 1000 PSI. Available with flange or base mountings. Spur gear design with anti-friction roller bearings.



VALVES

For operating one or more single or double-acting cylinders — 5 GPM to 85 GPM capacities at pressures up to 1400 PSI. Patented Hollow-Plunger* design with built in check valve.



CYLINDERS

Single-acting, double-acting and telescopic — from 1½" to 8" effective diameter — any stroke up to 120". Plain or eye type ends.

NOW, MORE THAN EVER BEFORE!

LOOK TO HYDRECO FOR ALL THREE

CHECK HYDRECO EXPANDED PLANT FACILITIES, PRODUCTION MACHINERY, NEW DESIGNS

COMPARE HYDRECO FOR QUALITY . . . FOR PERFORMANCE . . . FOR PRICE

*Hollow-Plunger protected by existing U.S. and Foreign Patents as well as patents applied for.

HYDRECO
HYDRAULIC CONTROL DEVICES
PUMPS · CYLINDERS · VALVES

THE MARK OF QUALITY

Write to
HYDRAULIC EQUIPMENT COMPANY
1112 EAST 222ND STREET • CLEVELAND 17, OHIO

INDEX OF *Products Advertised* IN THIS ISSUE

MATERIALS

Aluminum Alloys 8, 64, 69-70-71-72-73-74
Brass 8, 65, 191
Bronze 32C, 65
Carbide Alloys 287
Carbon 271
Carbon Graphite 20-21, 271
Copper Alloys 8, 65
Fabrics, Coated or Impregnated 217
Felt 185
Glass 238, 326
Jewel, Synthetics 312
Laminated Metals 58
Leather 64A-B
Magnesium Alloys 57, 72
Nickel Alloys ..... 2nd Cover, 36, 287
Plastics 6, 15, 35, 77, 173, 193, 216 246, 274, 275
Plastics, Laminated 32D, 228-229, 239 268, 275, 304
Powdered Metals 20-21, 271
Resins 217
Rubber & Synthetics 216, 217, 221 265, 272, 274
Silicones 152
Stainless Steel 56, 156, 270, 278, 307
Steel 161, 169, 205, 261, 278, 283
Wood 324
Zinc 76

STRUCTURAL PARTS

Bars 32C, 69, 73, 74, 283, 287
Castings 32, 53, 69, 73, 74, 197, 232 234, 255, 287, 291
Die Castings 47, 69, 73, 74, 281, 310
Expanded Metals 290
Extrusions 70-71, 74, 272
Fabricated Steel 60
Forgings 69, 73, 74, 245, 250, 302, 314
Metal Powder Parts 20-21, 30-31, 208 246, 271
Plates 69, 73, 74, 206, 287, 304
Rods 65, 69, 73, 74, 191, 304
Stampings 28, 32, 69, 73, 74, 179 202, 302
Tubing 14, 24, 46, 59, 65, 68, 69, 73 74, 187, 210, 258, 283, 287, 304, 309, 319
Wire 65, 73, 74, 254, 283, 287

FINISHES

Galvanizing 204
Non-Metallic 6
Paints & Lacquers 313
Rust Proofing 277

MECHANICAL PARTS

Adhesives 217
Balls 198, 300
Bearings, Ball, Roller, and Needle 4th Cover, 9, 40, 44, 48, 54, 80, 177, 188 192, 195, 200, 215, 224, 241, 242, 273 279, 295, 320
Bearings "Oil-less" 20-21, 30-31, 246 256, 271
Bearings, Sleeve 20-21, 30-31, 32C 222, 285
Bellows 29, 39
Belts 55, 219, 248, 249
Bolts, Nuts, Screws and Rivets 41, 52, 62, 73, 78, 167, 181, 218, 232 240, 254, 258, 263, 276, 280, 298, 300, 314
Blowers 22-23
Brakes 45
Brushes 321
Bushings & Grommets 32C, 272
Chains 13, 50, 227, 236-237, 248-249, 310
Clamps 69, 264
Clutches 45, 190, 236-237, 246, 267
Compressors 252
Containers 306
Controls 266
Coolers 39
Counters 17
Couplings, Flexible 196, 236-237 248-249
Couplings, Hose & Tube 264, 320
Engines 238, 272, 284
Fasteners 32, 41, 52, 58, 62, 69, 73 74, 78, 167, 181, 202, 218, 230, 232, 235 240, 243, 254, 258, 263, 272, 276, 280 286, 292, 298, 300, 314
Feeders 330
Floats 306
Gages & Instruments 171, 183, 244
Gears 4, 20-21, 75, 198, 252, 282 292, 314
Hose 55, 319
Hydraulic & Pneumatic Equipment 66-67, 163, 175, 202, 247, 252, 266, 267 269, 289, 296, 326
Joints 280, 288
Lubricating Equipment 214, 332
Materials Handling 13
Mountings 294
Packing, Gaskets, Seals 11, 12, 20-21 30-31, 55, 61, 63, 64A-B, 189, 207, 271 274, 330
Piping 69, 73, 74, 287
Pumps 32, 37, 66-67, 175, 232, 244 247, 252, 269, 324, 326, 330
Rings 64A-B
Screw Machine Parts 69, 73, 74, 218 280
Shafts 208, 220, 236-237
Sheaves & Pulleys 288
Speed Reducers & Motor Reducers 4, 186, 314
Springs 16, 32, 42, 202, 212, 296
Testing Equipment 284
Tapes 322
Thermostats 10, 29
Timers 194, 240, 262
Transmissions ..... 3rd Cover, 4, 13, 45 50, 75, 175, 219, 236-237, 248-249, 267 269, 295, 302, 322
Valves & Fittings 66-67, 183, 202 256, 269, 287, 289, 296, 306, 326
Vibration Dampers 212, 217, 265, 294
Vibratory Equipment 330
Washers 202, 218, 230
Wire Cloth 51, 250, 252

ELECTRICAL PARTS

Brushes 20-21, 30-31, 256, 271
Coils 316
Contacts 34, 58, 271
Controls & Control Equipment 2, 18-19, 32A-B, 49, 204, 209, 213, 230 256, 259, 260, 266, 271, 276, 305, 308 318, 322, 330
Counters 34
Electronic Equipment 18-19, 272
Heating Units 18-19, 272
Instruments 18-19, 171, 201, 293
Lamps 292
Motors ..... 3rd Cover, 18-19, 22-23, 25 26-27, 38, 43, 199, 203, 211, 231, 233 251, 257, 276, 297, 300, 302, 303, 317
Rectifiers 34, 330
Thermostats 10, 230
Timers 240, 257, 282
Wire & Cable 69, 73, 74, 154
Wiring Accessories 196, 230

DRAFTING ROOM EQUIPMENT AND SUPPLIES

223, 253, 280, 296, 302

FABRICATING METHODS AND SERVICES

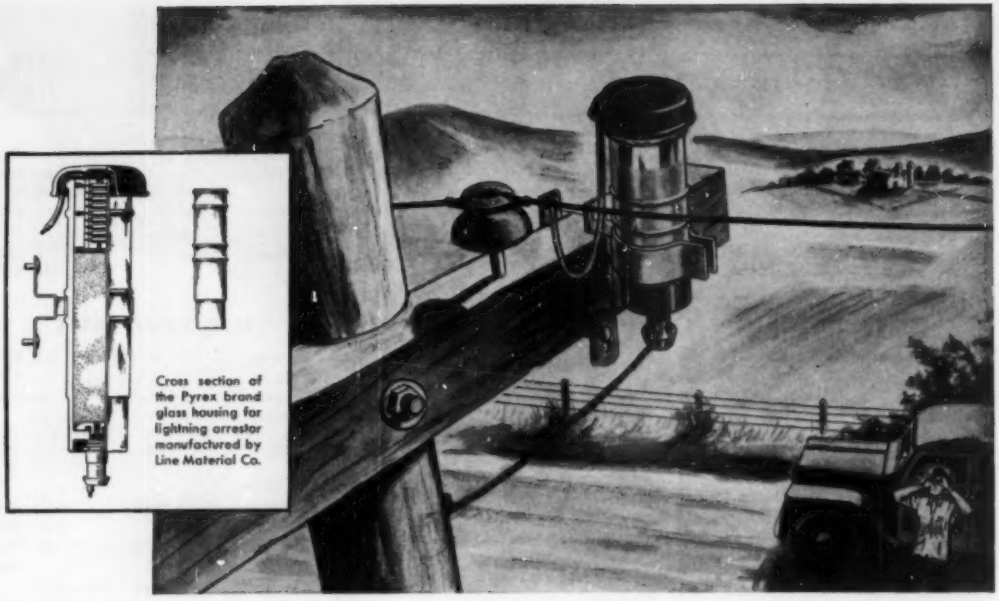
Assembling 58
Die Casting 69, 73, 74, 281
Engraving 314
Extruding 70-71
Forming 165, 264
Materials Handling 165
Molding 32D, 77, 193, 216, 221, 228-229 239, 244, 265, 274
Pressing 28, 69, 73, 74, 264
Shearing 284
Slitting 165
Stamping 28, 69, 73, 74, 284
Stitching 286
Welding 33, 165, 264, 287

ENGINEERING AND PRODUCTION SERVICES

232, 238, 299

BOOKS

234, 240, 242, 262, 266, 268, 270, 278, 282 286, 294, 301, 311, 314, 316, 318, 321



ENGINEERS SAW THROUGH THE PROBLEM...from the ground

The engineers who design lightning arrestors discovered Corning industrial glass and the answer to a power-line problem.

An arrestor must wait up there patiently—for years—in all kinds of weather—for an invading stroke of lightning. To perform its duty, the arrestor must short-circuit the stroke to ground and then instantly open the short circuit before the power current can follow to ground . . . But lightning is tricky. One stroke in fifty may impose extreme overloads on the arrestor, and may cause trouble.

The engineers knew that a lineman could spot that trouble if he could see inside the arrestor from ground level . . . And there was the idea that clicked . . . Use a glass body!

They found their glass body at Corning. A PYREX brand glass passed the tests with ease—electrical, mechanical, thermal, chemical. Corning knew how to make it into a difficult shape at low cost.

For designs that click, every engineer should keep Corning industrial glasses in mind. He should have a copy of Bulletin B-83—"Properties of Selected Commercial Glasses." He should have a copy of Bulletin B-84—"Design and Manufacture of Commercial Glassware." Send for your copies today.

CORNING GLASS WORKS PYREX **CORNING, N. Y.**

Corning means research in Glass

Technical Products Division: **Laboratory Glassware, Plant Equipment, Lightingware, Glass Pipe, Signalware, Gauge Glasses, Optical Glass, Glass Components**

ADVERTISERS INDEX

Accurate Spring Mfg. Co. 212
Acme Steel Co. 286
Air Associates, Inc. 266
All American Tool & Mfg. Co. 284
Allegheny Ludlum Steel Corp. 306
Allen Mfg. Co. 254
Allis-Chalmers Mfg. Co. 25, 37
Allis-Chalmers Mfg. Co., Tractor Div. 284
Allmetal Screw Products Co., Inc. 218
Aluminum Co. of America 69-70-71 72-73-74
Aluminum Co. of America—Die casting 73
Aluminum Co. of America—Fabricator 70-71
Aluminum Co. of America—Fasteners 73
American Chain & Cable Co., Inc. 254
American Felt Co. 185
American Hard Rubber Co. 216
American Hot Dip Galvanizers Assn. 204
American Magnesium Corp. 72
American Metal Hose Branch, American Brass Co. 319
American Screw Co. 52
American Society of Tool Engineers 320
Arkwright Finishing Co. 296
Arma Corp. 317
Armco Steel Corp. 156
Armstrong Cork Co. (Gaskets, Packing & Seals) 11
Arrow-Hart & Hegeman Electric Co. 32A-B
Arwood Precision Casting Corp. 232
Atlas Chain & Mfg. Co. 227
Automatic Electric Sales Co. 305

Bantam Bearings Div., Torrington Co. 48
Barber-Colman Co. 300
Barnes Co., Wallace, Div. Associated Spring Corp. 16
Beckett-Harcum Co. 202
Bethlehem Steel Corp. 60
Bijur Lubricating Corp. 214
Blackhawk Mfg. Co. 66-67
Blood Brothers Machine Co. 268
Bodine Electric Co. 303
Bound Brook Oilless Bearing Co. 246
Bridgeport Brass Co. 65
Briggs & Stratton Corp. 238
Bristol Co. 314
Brown Instrument Co. 213
Brown & Sharpe Mfg. Co. 171
Bunting Brass & Bronze Co. 32C
Bush Mfg. Co. 210

Cambridge Wire Cloth Co. 252
Carpenter Steel Co. 56
Carpenter Steel Co., Alloy Tube Div. 46
Cash Valve Mfg. Corp., A. W. 306
Century Electric Co. 251
Chain Belt Co. 248-249
Chicago Rawhide Mfg. Co. 64A-B
Clifford Mfg. Co. 39
Columbia Steel Co. 24
Commercial Shearing & Stamping Co. 284
Commonwealth Edison Co. 299
Continental-Diamond Fibre Co. 239
Continental Rubber Works 274
Corning Glass Works 328
Coto-Coil Co., Inc. 316
Crane Co. 183
Crocker-Wheeler Div., Ellicott Co. 26-27
Cuyahoga Spring Co. 296

Dayton Rogers Mfg. Co. 302
Delco Appliance Div.—General Motors Corp. 297
Dial Light Co. of America 292
Diefendorf Gear Corp. 292
Dixie Cowdrey Machine Corp. 232
Dodge Mfg. Corp. 295
Doehler-Jarvis Corp. 47
Dow Chemical Co. 15, 57
Dow Corning Corp. 152
Drop Forging Association 250
DuPont de Nemours & Co., Inc. E. I. (Plastics) 35
Durakool, Inc. 204

Eagle Signal Corp. 240
Earle Gear & Machine Co. 252
Eastman Kodak Co., Industrial Functional 253
Eastman Kodak Co., Industrial Photographic 223
Eaton Mfg. Co., Foundry Div. 32
Electric Auto-Lite Co. 32D, 154
Elliott Co, Crocker-Wheeler Div. 26-27

Fafnir Bearing Co. 224
Fawick Airflex Co., Inc. 190
Federal Bearings Co., Inc. 54
Federal Mogul Corp. (Equipment) 222
Finn & Co. 212
Flintkote Co. 217
Foote Bros. Gear & Machine Corp. 75
Formica Insulation Co. 268
Fulton Sylphon Div., Robertshaw-Fulton Controls Co. 29

Garrett Co., Geo. K. 202
Gast Mfg. Corp. 252
Gates Rubber Co. 219
General Electric Co.—Apparatus Dept. 18-19, 49
General Industries Co. 211
General Plate Co. 58
General Radio Co. 293
Gibson Co., Wm. D. 42
Goodrich Chemical Co., B. F. (Geon) 6
Goodyear Tire & Rubber Co. (Mech. Goods) 55
Gray Iron Founders' Society Inc. 291
Great Lakes Steel Div., National Steel Corp. 161

Hallco Bearing Div. of Marsam Enterprises Inc. 242
Hannifin Corp. 289, 296
Harper Co., H. M. 240
Hartford Steel Ball Co. 300
Hart Mfg. Co. 276
Haydon Mfg. Co. 262
Haynes Stellite Co., Unit of Union Carbide & Carbon Corp. 287
Heim Co. 44
Herbrand Div. of the Bingham-Herbrand Corp. 302
Heyman Mfg. Co. 196
Hoover Ball & Bearing Co. 192
Houghton & Co., E. F. 63
Howard Industries 276
Howell Electric Motors Co. 203
Hyatt Bearings Div., General Motors Corp. 40
Hydraulic Equipment Co. 326

Imperial Tracing Cloth Co. 280
Inland Steel Co. 206
International Nickel Co., Inc. Monel 36
International Nickel Co., Inc., Nickel Alloy ..... 2nd Cover

Johns-Manville Corp. (Packings). 189
Johnson Bronze Co. 285
Jones & Laughlin Steel Corp. 283
Jones Foundry & Machine Co., W. A. 288

Kaiser Aluminum & Chemical Corp. 64
Koh-I-Noor Pencil Co., Inc. 302

Laminated Shim Co., Inc. (Ancorlox) 276
Lavelle Rubber Co. 272
Leland, Inc., G. H. 302
Lewellen Mfg. Co. 322
Lima Electric Motor Co. 302
Linde Air Products Co. Unit of Union Carbide & Carbon Corp. 312
Linear, Inc. 207
Link-Belt Co. 9, 13
Litemetal Dicast Inc. 310
Littleford Bros., Inc. 264
Lord Mfg. Co. 294
Lumber Manufacturers, Inc. 324

"Noiseless"
BIN VIBRATORS
Make Stubborn Materials Flow Freely

VIBRATORY FEEDERS
Finger-Tip Control of the Rate of Bulk Material Flow

VIBRATORY PACKERS
Pack and Settle Materials in Containers and Molds

USE COMPONENTS OF *SYNTRON* DEPENDABLE QUALITY

SMALL PARTS FEEDERS
Single Line Feed — Piece by Piece

ELECTRIC VIBRATORS, promoting free-flowing materials out of bins, hoppers and chutes.

VIBRATORY FEEDERS, controlling the flow of materials in packaging machines, batching systems, etc.

VIBRATORY PACKERS, settling materials in containers and in molds.

SMALL PARTS FEEDERS, feeding small objects to automatic machinery, inspection belts, counting and packaging machinery.

VIBRATING GRIZZLIES, for rough scalping and separation.

VIBRATING SCREENS, removing foreign objects, lumps, etc., from foods, chemicals, ceramics.

SHAFT SEALS to eliminate leakage of gases and liquids from around rotating shafts of compressors, pumps, mixers, etc.

SCREW PUMPS, handling various grades of oil—crude, fuel, lube and hydraulic.

HOPPER LEVEL SWITCHES, controlling the amount of material in bins and hoppers — controlling batch weighing by volume.

SELENIUM RECTIFIERS for efficient conversion of A.C. to D.C. in all types of electrical equipment. From 1" sq. plates up to 6" x 12".

Write for catalog data

SYNTRON CO.
240 Lexington, Homer City, Pa.

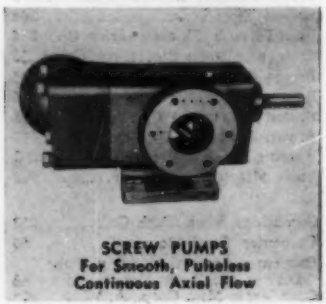
SELENIUM RECTIFIERS
As Individual Plates or Stacks

VIBRATING GRIZZLIES
Both Feed and Scalp With One Unit

HOPPER LEVEL SWITCHES
Control Maximum and Minimum Hopper Contents

VIBRATING SCREENS
Wet or Dry — Single or Multiple Decks

SHAFT SEALS
Replace Packing and Eliminate Leakage From Around Rotating Shafts



SCREW PUMPS
For Smooth, Pulseless Continuous Axial Flow

ADVERTISERS INDEX

McGill Mfg. Co., Inc. 200
McGraw-Hill Book Co., Inc. 234, 242 262, 266, 268, 270, 278, 282 286, 294, 301, 311, 314, 321
McGraw-Hill Catalog Service 240
McKee Glass Co. 238
Mahon Co., R. C. 33
Mallory & Co., Inc., P. R. 2, 34
Marion Electrical Instrument Co. 201
Marlin-Rockwell Corp. 241
Marman Products Co., Inc. 264
Master Electric Co. (Speedmaster) 3rd Cover
Meehanite Metal Corp. 53
Michigan Steel Tube Products 258
Michigan Tool Co., Cone Drive Div. 4
Midland Steel Products Co. 320
Miniature Precision Bearings, Inc. 320
Monsanto Chemical Co. 77
Morganite, Inc. 256
Morse Chain Co. 236-237
Mt. Vernon Die Casting Corp. 281
Mueller Brass Co. 191

National Motor Bearing Co., Inc. 61
National Paint, Varnish & Laquer Association, Inc. 313
National Screw & Mfg. Co. 298
National Tube Co. 24
National Steel Corp. 161, 261
National Vulcanized Fibre Co. 304
Newark Wire Cloth Co. 250
New Departure Div. Gen. Motors Corp. 80
New Hampshire Ball Bearings Inc. 240
New Hermes, Inc. 314
New Jersey Zinc Co. 76
Nice Ball Bearing Co. 195
Nicholson & Co., W. H. 306
Norma-Hoffman Bearings Corp. 279

Ohio Gear Co. 315
Ohio Seamless Tube Co. 68
Ohmite Mfg. Co. 259-260
Oilgear Co. 175
Orange Roller Bearing Co., Inc. 188

Packard Electric Div., Gen. Motors Corp. 199
Page Steel & Wire Div., Amer. Chain & Cable Co., Inc. 254
Paramount Oilless Bearing Co., Inc. 256
Parker-Kalon Corp. 41
Parker Rust Proof Co. 277
Penn Metal Co., Inc. 290
Perkins Machine & Gear Co. 282
Pesco Products Co.—Borg Warner Corp. 247
Pioneer Pump & Mfg. Co. 232
Pittsburgh Plate Glass Co.—Brush Div. 321
Precision Tube Co. 14
Progressive Mfg. Co. 292

Quinn Berry Corp. 193

R. B. M. Division of Essex Wire Corp. 318
Ramsey Chain Co., Inc. 310
Raybestos-Manhattan Inc., Packing Division 12
Redmond Co., Inc. 22-23
Reliance Electric & Engineering Co. 231
Republic Steel Corp. (Steel & Tubes Div.) 59
Revere Copper & Brass Inc. 8
Reynolds Wire Co. 51
Richardson Co. 275
Robertshaw-Fulton Controls Co. 230
Rockford Clutch Div., Borg-Warner 246
Rohm & Haas Co. 173

SKF Industries, Inc. 273
Sandvik Steel Inc. 205
Schatz Mfg. Co. 215
Scovill Mfg. Co. (Industrial Fasteners) 280
Set Screw & Mfg. Co. 232
Sewall Mfg. Co., R. B. 198
Shakeproof, Inc. 263
Sharon Steel Corp. 169
Simmons Fastener Corp. 243
Skinner Electric Valve Div., The Skinner Chuck Co. 256
Smith Corp., A. O. 38
Smith Corp., Winfield H. 186
Society of the Plastics Industry 246
Soreng Mfg. Corp. 230
Spencer Thermostat Division Metal & Controls Corp. 10
Sponge Rubber Products Co. 221
Square D Company 209
Stackpole Carbon Co. 271
Standard Electric Time Co. 194
Standard Locknut & Lockwasher Co. 230
Standard Pressed Steel Co. 62, 258
Standard Tube Co. 187
Steel Founders' Society of America 197
Stephens-Adamson Mfg. Co. 177
Stokes Machine Co., F. J. 244
Strom Steel Ball Co. 198
Sundstrand Machine Tool Co. 269
Synthane Corp. 228-229
Syntron Co. 330

Telechron Inc. 257
Thomas Flexible Coupling Co. 196
Timken Roller Bearing Co. (Industrial) ..... 4th Cover
Tinnerman Products, Inc. 78
Topflight Tape Co. 322
Torrington Co. 208
Torrington Co., Bantam Bearing Div. 48
Tourek Mfg. Co., J. J. 280
Townsend Co. 167
Trabon Engineering Co. 332
Transue & Williams Co., Stamping Div. 179
Twin Disc Clutch Co. 267

Union Carbide & Carbon Corp., Haynes Stellite Co., Unit 287
Union Carbide & Carbon Corp., The Linde Air Products Co., Unit 312
Unitcast Corp. 234
United Screw & Bolt Corp. 181
U. S. Graphite Co. 20-21, 30-31
U. S. Rubber Co. 265
U. S. Steel Export Co. 24
U. S. Steel Corp. 24

Veeder-Root Inc 17
Vickers, Inc. 163
Viking Pump Co. 324
Vulcan Electric Co. 272

Wagner Electric Corp. 233
Waldes-Kohinoor, Inc. 235
Wallingford Steel Co. 278
Warner Electric Brake Co. 45
Washington Steel Corp. 270
Weirton Steel Co. 261
Wel-Met Co. 206
Westinghouse Electric Corp. 43
Wheland Co. 255
White Dental Mfg. Co., S. S. 220
Whitney Chain & Mfg. Co. 50
Wiggins Oil Tool Co., E. B. 320
Williams & Co., J. H. 314
Wirebound Box Mfgs. Assn. 306
Wisconsin Motor Corp. 272
Wolverine Tube Div., Calumet & Hecla Cons. Copper Co. 309
Worcester Pressed Steel Co. 28
Wyman-Gordon Co. 245

Yoder Co. 165

■

PROFESSIONAL SERVICES 325

■

SEARCHLIGHT SECTION
(Classified Advertising)

EMPLOYMENT
Positions Vacant 325
Selling Opportunities Offered 325
Positions Wanted 325
Employment Services 325
BUSINESS OPPORTUNITIES
Offered 325

Trabon
LEADS IN AUTOMATIC LUBRICATION

PROOF!!!

12 years of continuous service on this four stand tandem cold mill

● This long period of continuous service is one reason why there are more Trabon Automatic Systems in operation than all other makes... time tells.

Trabon systems deliver the exact measured amount of lubricant to each bearing —no excess to damage the product being manufactured.

Trabon oil and grease systems are SAFE... POSITIVE ... AUTOMATIC .. SEALED... result in lower operating costs, increased production and protection to men and machinery.

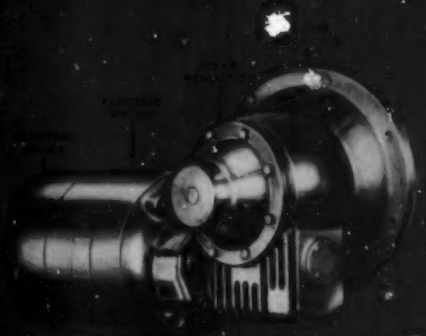
Backed by 20 years of experience in engineering and installing lubrication equipment, Trabon can save thousands of dollars for you.

Regardless of the size or type of your machine — whether single or tandem mills for stainless, alloys, aluminum or brass — there is a Trabon system to fill your need. Call or write today.

WRITE FOR YOUR COPY OF BULLETIN 469

TRABON ENGINEERING CORPORATION
1814 EAST 40th STREET • CLEVELAND 3, OHIO

Trabon
OIL AND GREASE SYSTEMS



The power drives on this machine incorporate an electric motor, a gear reduction, an electric brake and a flange mounting . . . all standard Master units that easily combine into one compact, integral power-package that's just right for this machine. This permits many parts to be stripped away from both the power unit and the completed machine . . . makes a job that's all muscle, no fat.

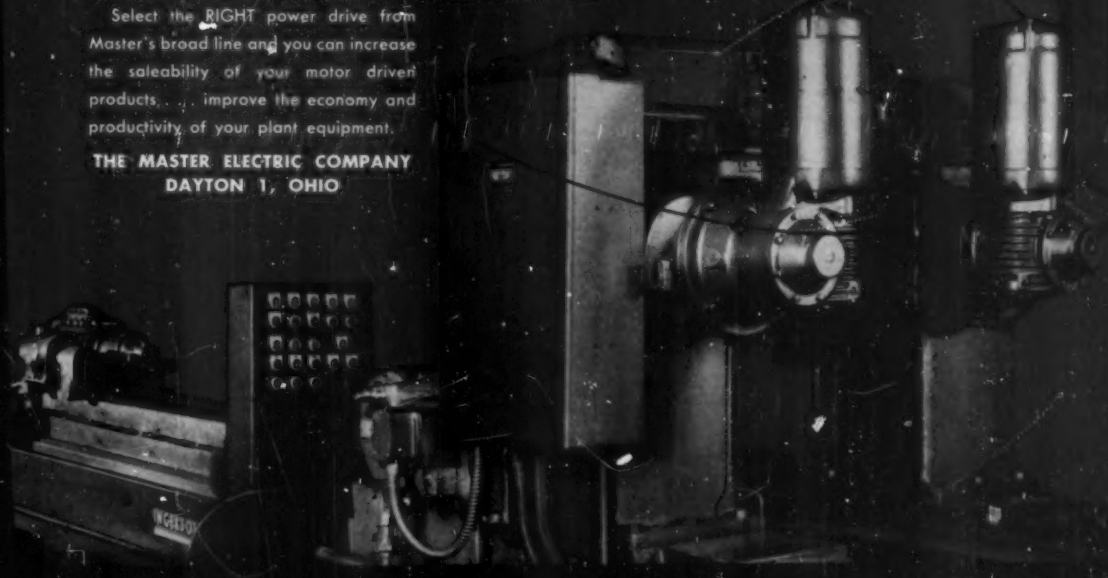
Master Motors, available in thousands and thousands of types and ratings (up to 150 HP) give you an enormous selection of integrally built power drives with which you too can easily secure these same results.

all muscle . . . no fat

Open, enclosed, splash proof, fan-cooled, explosion proof . . . horizontal or vertical . . . for all phases, voltages and frequencies . . . in single speed, multi-speed and variable speed types . . . with or without flanges or other special features . . . with 5 types of gear reduction up to 432 to 1 ratio . . . with electric brakes . . . with mechanical variable speed units . . . and for every type of mounting . . . Master has them all and so can be completely impartial in helping you select the one best motor drive for YOU.

Select the RIGHT power drive from Master's broad line and you can increase the saleability of your motor driven products . . . improve the economy and productivity of your plant equipment.

THE MASTER ELECTRIC COMPANY
DAYTON 1, OHIO



New TIMKEN® "Double-Zero" bearing has twice the accuracy of any TIMKEN bearing ever made!

PRODUCTION BEING INCREASED TO MEET GROWING DEMAND AS "00" BEARING BRINGS NEW PRECISION TO MORE AND MORE PRODUCTS

Twice as accurate as the Timken® "Zero" bearing—previously the most accurate Timken bearing on the market—the new "Double-Zero" bearing offers industry great new opportunities for high precision. Run-out tolerance in the new "Double-Zero" is only 75 millionths of an inch!

This amazingly low run-out has resulted in quick adoption of the "Double-Zero" bearing for lathe spindles, grinding-machine spindles, small precision rolling mills, dividing heads, and gear cutting machines. And production of the "Double-Zero" has been repeatedly upped to meet the growing demand for greater precision.

The extremely high accuracy of the "Double-Zero" bearing has been made possible by The Timken Roller Bearing Company's development of new measuring devices, specialized machine tools, and improved manufacturing methods.

"Double-Zero" sizes and types are shown in the chart below. For more information write The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.

A PRECISION TIMKEN BEARING FOR EVERY REQUIREMENT			
CLASS	"00" (DOUBLE-ZERO)	"0" (ZERO)	"3" (THREE)
RUN-OUT	.000075"	.000150"	.000300"
TYPES AVAILABLE	Standard Single Row	Standard Single Row	All types
SIZE RANGE	Up to 10" O.D.	Up to 12" O.D.	Up to 12" O.D.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ◎ AND THRUST →◎← LOADS OR ANY COMBINATION ✳